# Collaboration patterns in the Dutch railway sector

## Using game concepts to compare different outcomes in a unique development case

Bekius, Femke; Meijer, Sebastiaan; de Bruijn, Hans

**DOI**
10.1016/j.retrec.2018.06.011

**Publication date**
2018

**Document Version**
Final published version

**Published in**
Research in Transportation Economics

**Citation (APA)**
Bekius, F., Meijer, S., & de Bruijn, H. (2018). Collaboration patterns in the Dutch railway sector: Using game concepts to compare different outcomes in a unique development case. *Research in Transportation Economics*, *69*, 360-368. https://doi.org/10.1016/j.retrec.2018.06.011

Research in Transportation Economics 69 (2018) 360–368

Contents lists available at ScienceDirect

Research in Transportation Economics

journal homepage: www.elsevier.com/locate/retrec

# Collaboration patterns in the Dutch railway sector: Using game concepts to compare different outcomes in a unique development case

Femke Bekius[a,*], Sebastiaan Meijer[a,b], Hans de Bruijn[a]

[a] Delft University of Technology, Jaffalaan 5, 2628 BX Delft, the Netherlands
[b] KTH Royal Institute of Technology, Halsovagen 11C, Huddinge, Stockholm, Sweden

ARTICLE INFO

*JEL classification:*
C70
D73
D81
L92
O32
P51

*Keywords:*
Decision-making
Dutch railway sector
Game theory
Case study
Innovation processes

ABSTRACT

Decision-making on changes to large infrastructural systems is complex. It involves many actors, the system shows unpredictable behaviour and the environment in which decision-making takes place is dynamic. In a unique development case of the Dutch railway sector two decision-making processes regarding the same issue are performed in two consecutive years. Although, from a technical perspective, the elements of the processes are similar, the decisions in each year are different. In this paper, we use game concepts to explain the different outcomes. Other frequently adopted decision-based models that focus on the technical perspective do not distinguish between both processes. Game concepts are able to reveal the hidden actor and context dynamics of the process and provide action perspective. To identify the game concepts present in the decision-making process, we first consider whether these concepts are mentioned in interviews with decision-makers in our case. Thereafter, we interpret the processes using the identified game concepts. The fact that, in the second year, more external issues are discussed and pressure increased created room for another decision.

## 1. Introduction

The A2 corridor, between Amsterdam and Eindhoven, is the busiest part of the Dutch railway network. Since the number of passengers is expected to increase in the near future there is a need for more capacity, which means running more trains per hour. This, however, cannot be done at the expense of the performance level of the system, e.g., measured in number of delays (Tweede Kamer der Staten-Generaal, 2015a). Many improvements of the system, such as constructing new infrastructure, changing behaviour of operators and introducing new trains, are planned to, or have partly, been implemented to support the increased capacity. Therefore, ProRail (infrastructure manager) and NS (main operating company) have to decide: has the performance of the system improved enough in order to increase the frequency of the number of trains per hour at the A2 corridor?

In this paper we reflect on the collaboration case between ProRail and NS concerning the decision described above. The decision-making process has been performed two times, respectively in years 2015 and 2016. The processes are similar since in both situations the same decision needs to be taken by the same actors and both processes are supported by the same improvement program. Moreover, the decisions are made in uncertainty since the performance level of the system is not known at the moment of decision-making and the technical complexity of the system did not change. Interestingly, the final decision, i.e., the outcome, of both processes is different. The purpose of this paper is to explain these different outcomes using game concepts. The different outcomes cannot be explained from a (single) technical perspective, for example, comparisons of lists with feasibility of various (technical) aspects of the process do not reveal why the outcome is different. Therefore, we take into account the actor and context dynamics of the process (de Bruijn & Herder, 2009): actors may adopt new roles or responsibilities, and the request from the political environment may change.

Game concepts, derived from existing work in game theory and complex decision theory, represent the actor and context dynamics of the process. Therefore, to explain the different outcomes of the decision-making processes, we characterize their hidden dynamics using game theoretical concepts. Game theory and complex decision theory have a natural link considering their elements: the actors, the decisions, payoffs and information (Rasmusen, 2007). However, as the theory supports, in a complex decision-making processes more elements are involved (de Bruijn & ten Heuvelhof, 2008; Klijn & Teismand, 1997; Koppenjan & Klijn, 2004). Criticisms on the use of game theory advances that the method cannot cover the richness of the empirical decision-making process and an entire process is forced into one game

* Corresponding author.
*E-mail addresses:* f.a.bekius@tudelft.nl (F. Bekius), Sebastiaan.Meijer@tudelft.nl (S. Meijer), J.A.deBruijn@tudelft.nl (H. de Bruijn).

https://doi.org/10.1016/j.retrec.2018.06.011
Received 29 November 2017; Received in revised form 17 June 2018; Accepted 22 June 2018
Available online 11 July 2018

concept (Bennett, 1987; Binmore, 1987). This results in an oversimplification of the situation that is not useful for the decision-maker when applying it to real-world cases. To mitigate the possible simplification, we use multiple game concepts to characterize the process. Our approach is different from more general game theory applications since our concepts are able to cover rich policy situations and give nuance to different incentives of different actors. Moreover, the game concepts entail a prescriptive nature.

To identify the game concepts we first consider interviews conducted with decision-makers involved in the process. Based on the definition of the game concepts we identify different elements of the concepts. Thereafter, we perform a second analysis and interpret the game concepts in the decision-making processes based on the case description. First verifying the presence of the game concepts in the process by decision-makers involved and then performing the interpretation strengthens the paper's conclusions.

The paper is structured as follows: Section 2 provides a brief overview of alternative decision-based models and how our approach is different from these. In Section 3 the methods used to identify the game concepts are introduced and it presents the game concepts considered. Section 4 contains a description of the case study. Thereafter, we characterize the decision-making process using game concepts in Section 5. Finally, Section 6 gives a conclusion before we discuss the results and propose directions for further research in Section 7.

## 2. Decision-based models

In this section we briefly introduce some decision-based models and explain how our approach is different from these models. First, we discuss a couple of game theoretical models used in the transportation literature. Second, we mention other approaches that are based upon game theory. Third, we introduce a couple of general, well-known, decision-based models.

There are many examples of game theoretical models applied to transportation problems (Adler, Fu, Oum, & Yu, 2014; Adler, Pels, & Nash, 2010; Cantarelli, Chorus, & Cunningham, 2013; Hollander & Prashker, 2006; Mozafari & Karimi, 2011; Oruç & Cunningham, 2014; Takebayashi, 2014, 2015). Most of these papers aim is to model one particular situation in detail in order to find optimal or stable outcomes, so called Nash equilibria, assuming that actors involved will behave rationally and want to maximize their payoff. Our approach aims to understand the process of decision-making and thus does not focus on modelling one particular situation in detail. We identify several game concepts, which are based upon existing game theoretical models like Principal-Agent model and n-player Prisoners Dilemma, in the course of decision-making since the mechanisms evolve over time due to the dynamics of the process. The game concepts enable us to include the context of the decision as well resulting in a richer characterization. Furthermore, assumptions on rationality of the actors and maximizing payoffs are not made explicitly. Where, in general, game theoretical models do make these assumptions, our approach focusses more on the incentive structures of actors and revealing the main dilemmas of the decision-making process. Another aspect in which our approach differs: we do not aim to provide a definite answer or judge wrong/right outcomes, rather, we aim to prescribe a perspective of action for the actors involved.

Less theoretical game approaches include game structuring methods (Cunningham, Hermans, & Slinger, 2014). This is a subset of problem structuring methods which have the aim to develop commitment of action among the stakeholders involved (Rosenhead & Mingers, 2001). Examples of game structuring methods are Analysis of options (Ackhoff et al., 1969), Conflict analysis and Meta game analysis (Fraser & Hipel, 1984), Hyper game analysis and Drama theory (Bennett, 1977), Exchange modelling (Coleman, 1972), and Theory of moves (Brams, 1994). These five game structuring techniques have their roots in game theory. The game concepts in this paper are different compared to these techniques since their roots are not solely in game theory but also in public administration theory. Hence, they cover a wider range of possible mechanisms and patterns in decision-making processes. Moreover, the literature on game structuring methods has tended to engage more on theoretical concerns rather than on applications in real-world complex decision-making.

Some well-known decision-based models are Multi-Criteria Decision-Analysis (MCDA) (Dodgson, Spackman, Pearman, & Phillips, 2009; Ishizaka & Nemery, 2013), Cost-Benefit Analysis (CBA) and Analytical Hierarchy Process (AHP) (Zahedi, 1986). An overview of group decision MCDA frameworks can be found in (Nikas, Doukas, & Martínez López, 2018). The models compare different alternatives, or variants, based upon various evaluation criteria that can have different weights. Usually, the criteria are measures which can be made quantitative. This also shows the difficulty in using these models. Namely, in complex decision-making process not all aspects of the process are quantifiable. For example, a big snow storm can cause serious delays of trains and stranded passengers at train stations. The way in which the railway sector deals with this situation influences the political environment which then can have an impact on how future decisions regarding the railway system will be made. In the case study, presented in Section 4, these decision-based models are unable to show the difference between both decision-making processes since they focus mainly on technical criteria. Apparently, there are aspects of the process that are not taken into account but do influence the outcome of the process. Our approach is able to show the difference between the two processes by including the context dynamics of the process.

In short, our approach is different from the before mentioned models in the following aspects: (i) the game concepts are based upon existing work in game theory and public administration, which aims to bridge the disciplines, therefore the game concepts are a policy rich approach including dynamics and context of the process; (ii) the different game concepts are able to influence and activate one another and together are able to reflect upon and explain a large part of the process and we do not aim for analysing the process with one single model; (iii) at the same time, the game concepts reduce the complexity of the process to what we call the essence. This means we leave out factors that influence the process, not saying that they do not matter; (iv) whether the game concepts appear depends on the context of the process, we focus on incentive structures and main dilemmas of the process rather than finding an optimal solution.

## 3. Methodology

The methods we use in this study can be split in two parts: (i) the identification of game concepts (inductive and deductive) in the decision-making process, and (ii) an interpretation of these concepts in the decision-making process.

### 3.1. Identification of game concepts

The first part is the identification of game concepts in interview transcriptions with various decision-makers involved in the process. First, we propose a characterization of four game concepts that captures the context, the process, the results and the risk of the game concepts. The characterization is based on literature: approximately 10 papers per game concept are investigated. Section 3.2 gives a description of the four game concepts and their elements.

Second, we conduct interviews with decision-makers, from both operational and strategic level, from ProRail, NS and the Ministry of Infrastructure and Environment (MIE). In total 28 interviews are conducted in two rounds. The first round took place directly after the first decision was performed and the second round was performed after the second decision was made. Nine interviewees are involved in both interview rounds. Shifts in roles and functions explains why not exactly the same people could be interviewed in both years. More people are interviewed during the first round because some actors that were

**Table 1**
Background of interviewees.

| | 2015 | 2016 |
|---|---|---|
| Total number of interviewees | 16 | 12 |
| Strategic level of infrastructure manager (ProRail) | 1 | 1 (1)[a] |
| Operational/tactical level of infrastructure manager (ProRail) | 4 | 2 (2) |
| Strategic level main operating company (NS) | 3 | 2 (2) |
| Operational/tactical level main operating company (NS) | 5 | 6 (4) |
| Ministry of Infrastructure and Environment (MIE) | 2 | 1 (0) |
| Others[b] | 1 | 0 (0) |

[a] The number within the brackets reflects how many of the people that participated in the interviews in the year 2015 also participated in the year 2016.
[b] Experts or external parties involved in the process.

involved in the process in year 2015 were no longer part of in the year 2016. Table 1 specifies the interviewees of both years.

The interviews follow a semi-structured protocol covering the following themes: actors, their function, their interests, strategies performed, explanations for the decision, important moments, complexity, uncertainty, information, issues on content and context, and possible improvements of the process. The interviewees are asked to score the importance of several aspects of the decision-making process for both years on a scale from 1 to 4 (1 = not important, 4 = very important). No major differences are reported. In particular, technical aspects of the process, such as complexity, content of issues and performance improvement are evaluated similar for both years. New actors, time pressure and ownership are aspects of the process that show a small difference. The interviews are transcribed and we use the transcription for identification of the game concepts.

Third, we investigate the transcriptions and code, i.e., mark sentences, which cover aspects of the elements of the game concept. For example, a sentence in the interview transcription representing an aspect of the context elements of the Multi-Issue game is coded by M-I_C.

Fourth, we score the elements per game concept per interviewee. When at least two different elements of the same game concept are mentioned at least once during the interview we say the game concept is present, and thus we identify the game concept in this interview. The comparison of the percentage of interviewees that mentions a game concept in 2015 and 2016 is presented in Table 2 in Section 5.

The second part conveys our interpretation of the game concepts we identified in the decision-making process. It is a free interpretation of the authors based on the data available to them. In Section 4, we present a description of the decision-making process based on the interview data, observations during meetings and decision moments, and internal documentation from the organizations. The resulting case description has been discussed and verified with people from ProRail and NS involved in the decision-making process. For both processes the different elements (context, process, results and risks) of the game concepts are considered. The central question is: are the games played differently? If so, which elements are different and why is that the case? The results of the interpretation can be found in Section 5.

### 3.2. Game concepts

This section introduces four different game concepts: Multi-Issue (M-I) game, Volunteers Dilemma (VD), Cascade game (CG) and Principal-Agent (P-A) game. The description is based on the elements of the game concepts: the context, the process, the results and the risks.

#### 3.2.1. Multi-Issue game

Multiple actors with different incentives reach a consensus in a process that was in a deadlock position in the first place. A deadlock means that the actors are unable to agree on a single-issue and no consensus is reached. By bringing more issues at the table, the agenda is broadened, actors start playing the game of give-and-take, there is room for manoeuvre and hence consensus about the decision can be the final result (de Bruijn & ten Heuvelhof, 2008).

*Context*. In a situation with multiple actors having different responsibilities and interests regarding the system; the actors form a network of interdependencies; the decision-making process results in a deadlock where pressure does not help, the M-I game can be activated.

*Process*. The game is played by introducing new issues, called broadening the agenda, and assuring some potential pain and gain on the agenda for every actor. Moreover, linkage between, negotiation about and exchange of issues takes place. The focus is on the actors involved and on the process of decision-making: a plan follows the negotiations.

*Results*. Room for a certain (different) decision is created by broadening the agenda. Linking of issues happens and types of issues are specified such that the game of give-and-take is played. Negotiated knowledge, incentives for cooperation, participation in process, learning about content, knowledge about actors and their relations, and peer pressure arise.

*Risks*. The game develops into a so called 'free-fight' or becomes overcomplex (Bekius, de Bruijn, Cunnighmam, & Meijer, 2016; de Bruijn & Herder, 2009; de Bruijn & Heuvelhof, 2002; de Bruijn & ten Heuvelhof, 2008; Sebenius, 1983).

#### 3.2.2. Volunteers Dilemma

The game explains why one or more actors take the responsibility for the group to prevent a worst-case-scenario from happening. Performing wait-and-see behaviour is beneficial, but increases the risk for a bad outcome of the decision-making process.

*Context*. In a situation with multiple actors having diffuse responsibilities regarding the system, but together being responsible for the entire functioning of the system; pressure towards the decision increases; uncertainty about which decision to make increases; a 'dangerous event or belief' might lead to unfavourable results; and wait-and-see behaviour is present (de Bruijn & ten Heuvelhof, 2008), the VD can be activated. In short, the optimal decision for the individual, waiting for someone else to act, contrast the optimal decision for the group, at least one individual should act.

*Process*. Actors perform internal (individual) consideration of whether they will act as 'volunteer', meaning taking a decision, or not. Reasons why someone would volunteer include expecting personal blame else ways and that someone should take responsibility for the group. Since it is a difficult decision to make wait-and-see behaviour is observed by the actors.

*Results*. At least one actor did volunteer or no one did. In the first case, this person might be blamed or not. Furthermore, the, so called, showstopper that explicated the game is known. In the second case, a worst-case-scenario might happen. Overall, the game shows whether cooperation between actors took place. If the cooperation is limited it is more likely that the game will reveal itself.

*Risks*. No actor feels the need to volunteer since the risks are too high or everyone expects the others to volunteer. Available volunteers are not discovered since they are present at other levels of the organization (Archetti, 2009; Diekmann, 1985; Goeree & Holt, 2000; de Jong, Tuyls, & Verbeeck, 2008).

#### 3.2.3. Cascade game

The tendency of intelligent actors, in cases of uncertainty, to follow the decision of others independent of the quality of the content of the decision.

*Context*. In a situation where decisions are made in sequence, path-dependency exists; different actors are involved in different decisions and they have different incentives regarding the decision; the decision space is usually limited, the CG can be activated.

*Process*. In the process, the outcome of a decision taken at one level forms the input for the decision at the next decision level. Moreover, actors have private information and observe the outcome of the previous decisions on which they base their own decision. Do I follow the decision of others or not?

*Results*. A decision can spread through the various levels of decision-making, the constitution of these levels including the outcome for each level is a result. Irrational decision-making can be explained by tracking how (in)correct information leads to the final decision, resulting in an overview of dependencies between decisions made at different levels.

*Risks*. A cascade of decisions can be wrong, it can lead to sub-optimal outcomes and occur easily in round the table sessions (Anderson & Holt, 1996; Bikhchandani, Hirshlleifer, & Welch, 1992; Easley & Kleinberg, 2010; Gehlbach, 2006).

#### 3.2.4. Principal-Agent game

In a hierarchical relation between principal and agent, the principal is dependent on the agent because of its knowledge and expertise regarding a certain decision. The game explains the power position of the subordinate, i.e., the agent.

*Context*. In a situation where two actors with different power positions are present, the agent and the principal; actors have asymmetric information, in general, the agent has more knowledge and expertise on the subject than the principal, the principal might have more knowledge about the objective; actors have opposite interests, the P-A game can be activated.

*Process*. The process is executed in two steps. Usually, first, a contract is signed between principal and agent defining a reward for the actions performed by the agent on behalf of the principal, or a penalty when actions are not performed as desired. Hereby the decision-making authority is (partly) delegated to the agent and the principal cannot control its actions. Second, the agent presents the outcome of the actions to the principal.

*Results*. The agent either accepts or rejects the proposed contract and provides an outcome that either satisfies the principal or not. The principal then accepts or rejects the outcome of the agent. The principal is the affected party, its payoff depends on the actions performed by the agent. The other way around, the payoff of the agents is dependent on the reaction of the principal.

*Risks*. By not accepting the decision of the agent the principal damages the relationship with the agent. The other way around, by not performing the expected actions the agent damages the relationship with the principal (Braun & Guston, 2003; Gintis, 2000; Laffont & Martimort, 2002; Morrow, 1994; Rasmusen, 2007; Slinger, Cunningham, Hermans, Linnane, & Palmer, 2014; Stauvermann, 2004).

## 4. Case study of the Dutch railway sector

This section presents the complexity and a short description of the decision-making process of the Dutch railway sector.

### 4.1. Complexity of the decision

The complexity of the decision-making process can be characterized by system level, actor level and context level. This is in line with the literature on complex decision-making processes which provides three explanations for the non-linear, erratic and sometimes even chaotic behaviour of the decision-making process (de Bruijn & Herder, 2009; de Bruijn & ten Heuvelhof, 2008; Koppenjan, Veeneman, Voort, Heuvelhof, & Leijten, 2011; Teisman & Klijn, 2008). First, multiple actors are involved with different perspectives and separate responsibilities regarding the system. The actors are not hierarchically organized but form a network of interdependencies. Second, many uncertainties regarding the system exist. The sub- and aspect systems of the railway system are interdependent. For example, a change in a regional subsystem influences the performance of the national system. Since no one can oversee the entire system the influence of these changes is not always known. Third, the environment is dynamic. External factors, such as heavy winter weather, media and politics will have an influence on decision-making. In addition, the network of actors, and their position, involved in the process and the content of problems and solutions might change over time.

#### 4.1.1. System level

The railway system consists of several interdependent sub and aspect systems and each of them requires specific knowledge. The system needs to improve in order to keep the current performance level, measured by, among others, defects on infrastructure and delays of trains, while increasing the frequency of trains. The complexity lies in the fact that it is not known whether the improvements on the various sub and aspect systems together would result in the desired performance level. “First, the performance of the system needs to be improved, before we can do something else” (project manager, main operator). Moreover, the collective of improvements on the system are not visible at the moment of decision-making. For example, do improvements on the infrastructure together with improvements on trains and driving behaviour of operators mean that the overall system performance is improved? Therefore, no one could ensure the desired performance at system level.

#### 4.1.2. Actor level

Three main actors are involved in the decision-making process: ProRail, NS and the Ministry of Infrastructure and Environment (MIE). ProRail and NS are functionally organized and have separate responsibilities regarding the system. They cooperate to let the entire system function. Currently, there is a shift from separate decision-making with formal transitions between ProRail and NS, towards a process with joint preparation and actual decision-making without change of responsibilities between the organizations. This new type of decision-making includes performance levels, and the operational measures, explicit in the process of decision-making. The performance levels are established in contracts with the government (van de Velde, Jacobs, & Stefanski, 2009). ProRail and NS have a joint interest to achieve the desired performance levels. In the decision-making process, the decision is taken in different decision-making levels. This means that the decision made at one level forms the input for the decision taken at the next level. In these decision-levels the different actors, as well as the strategic and operational levels, of the organizations are included. The strategic level fears out-of-control situations while the operational level is more concerned with daily disruptions. “We are mainly concerned with big disruptions since this has a major impact on our reputation” (strategic level, infrastructure manager). The interest of MIE is to have the high frequency timetable implemented since they invested money in it. Moreover, they constitute the contracts including the performance levels.

#### 4.1.3. Context level

The context of the decision is important for the decision-making process and several elements can be enumerated. The media reports about full trains during rush hours. Alignment and commitment of organizations is necessary for the collaboration program to succeed. Issues such as reputation, culture of the organizations, overpromise and under deliver play a role, and discussions around the Parliamentary investigation (Tweede Kamer der Staten-Generaal, 2015b) have an impact. Moreover, new actors with limited railway experience enter the process which is of influence on the decision-making. “There are different players, a new CEO at the main operator company, the governance is arranged differently and people have a different role” (strategic level, main operator).

### 4.2. Essence of the decision-making process

In this section the decision-making process, including the two different outcomes, is presented and subheadings convey the essence of the different phases in the process.

#### 4.2.1. Uncertainties increase

The inclusion of performance levels in the decision-making leads to many uncertainties. They include technical uncertainties regarding the system, but also institutional and actor uncertainties. For example, conflicts regarding who decides about what and when appear. “It was clear that alignment was necessary, but it took quite a long time to decide who had the final vote on which aspect” (operational director, infrastructure manager). Multiple system issues which result in involvement of different departments across the organizations emerge. Some issues focus on the A2 corridor, such as the implementation of new trains, while others have an effect on the entire country, for instance the introduction of new operational procedures at the control centres. As a result, many actors with different responsibilities regarding the system and different perspectives on the decision to be made are involved. Additionally, time pressure towards taking a decision is present which makes the existence of many uncertainties problematic. “There is a huge barrier for people to communicate a red box,[1] they rather prefer to communicate an orange box while saying we will fix it” (operational director, infrastructure manager).

#### 4.2.2. Operational level initiates decision

Towards the decision deadline, operational decision-makers are asked to assure the performance level of their part of the system. It is their responsibility to provide an advice about the decision to increase the frequency of trains or not. Given the history and culture of the Dutch railway sector, no one is expected to say ‘no’. However, the implementation of new station Utrecht (Flow Trough Station Utrecht, DoorStroom Station Utrecht (DSSU) in Dutch) together with a frequency increase might cause too many problems and burden the performance levels in case of disruptions. Close to the decision deadline, the responsibility for the issue is taken by one actor at operational level resulting in a negative advice from operational level. “First it needs to be better, before we can actually have more trains” (infrastructure manager, main operator). Consequently, the advice spreads through the various levels of decision-making and is followed up by the decision-makers at those levels.

#### 4.2.3. Decision is accepted

Finally, the decision is adopted at strategic level and communicated to MIE. They are surprised by the outcome of the decision at a moment they cannot influence it anymore. “For a number of people the decision came as a surprise … When the decision was already made we got informed” (ministry). Their influence is limited since the deadline for making changes in the new timetable has already passed. Therefore, MIE accepts the decision, but with the additional desire for a positive, meaning ‘yes’, decision next year. “Everyone is committed to a positive decision” (ministry). A so called burden of the past is created.

#### 4.2.4. New start of the process: still many uncertainties

Half a year after the ‘no’ decision, the improvements of the system, necessary to ensure the desired frequency increase, are still not visible in the operation. At this stage, the operational level is the main representative of the process. Wait-and-see behaviour is observed and issues such as ownership and responsibility become evident. “We are one year further, and we are playing the same game, one level higher, based upon periodic progress reports” (operational director, infrastructure manager).

#### 4.2.5. Strategic level interferes

Because of these ownership and responsibility issues, the strategic level gets involved and urgency regarding the improvements spreads through the system. A shift in power and control regarding the situation, from operational level to strategic level, is observed. The stabling and serving problem becomes a major issue as well as the future stability of a high frequency timetable. “Major issues are and will be the stabling and serving problem and the future stability” (program manager, main operator). Unless issues which influence the performance levels negatively arrive at the table none of them seems to be a showstopper for the decision. Or, in other words, no one takes the responsibility for those issues and frames them as being critical issues regarding the desired performance level. Additionally, the promise towards MIE of last year becomes part of the discussion, even as reputation and the necessity of the frequency increase concerning the fact that trains are full. “Full trains is becoming an issue, especially at the A2 corridor, and why are we increasing the frequency, to solve the full trains issue” (strategic level, main operator).

#### 4.2.6. Decision has to be made: changing roles

Pressure from strategic level, in a final stage of the decision-making process, results in intensive collaboration at operational level. “Focus has improved and the game became more serious” (infrastructure manager). At this stage MIE becomes part of the decision and is willing to utilize the space available within the contract regarding the performance level. There are shifts in power and responsibilities between actors from strategic and operational level, as well as, between ProRail and NS, and MIE. It is in the interest of the Ministry to have ProRail and NS deciding positively since they promise a high frequency timetable to the Parliament. This shows that the power position of MIE is different towards NS and ProRail, and towards the Parliament. In fact, this results in a second burden of the past.

Two consecutive processes regarding the same decision conclude in different outcomes. One could say that the promise of a positive decision made after the ‘no’ in the first year leads to the different result. However, this explanation is too simple. Clearly, many more elements play a role. In interviews, decision-makers involved are asked to score the importance of several aspects of the process when comparing both years. Technical aspects, such as complexity of the process and performance improvement, received the same evaluation for both years. Aspects that scored differently are involvement of new actors, time pressure and ownership. In the next section, we interpret the difference in outcomes of our case study using the four game concepts.

## 5. Characterization of differences

This section contains a comparison between the decision-making processes of two consecutive years (2015 and 2016) using the game

[1] The assessment framework communicates the feasibility of the frequency increase by then end of year 2017 based upon several aspects that are assigned a red, orange, yellow or green box. A red box means that the aspect does not contribute to the feasibility of the frequency increase.

concepts. First, the questions whether decision-makers mention the game concepts elements is answered. Second, we explain whether the games are played differently in both years, and if so, which elements are different and why. The notable aspects of the game concepts that are different between the two consecutive years are listed in separate tables for each game concept.

The results from the identification of game concept elements in the interview transcription data is interpreted as follows: when an interviewee refers to aspects of at least two different elements of the game concept at least one time, the game concept is identified. Some examples mentioned are: “It played a role with the stabling and serving problem and future stability, to me this is a different decision but in the end this was included as well” (ministry, aspect of M-I game). “And for this it was necessary that someone took the decision and said, this is not possible, I do not want to take the risk because it is part of my domain and I cannot guarantee it” (infrastructure manager, aspect of VD). “Room for another decision is maybe a bit bigger because of shifts in incentives towards showing what we have promised instead of showing that I know what needs to happen and that this cannot continue like this” (infrastructure manager, aspect of PA). Table 2 presents the percentage of interviewees that mentioned the game concept for both decision-making processes.

**Table 2**
Results from coding interviews with game concept elements.

| Game concept | 2015 | 2016 |
|---|---|---|
| Multi-Issue game | 81,25% (=13/16) | 100% (=12/12) |
| Volunteers Dilemma | 68,75% (=11/16) | 75% (=9/12) |
| Cascade game | 87,50% (=14/16) | 91,67% (=11/12) |
| Principal-Agent game | 81,25% (=13/16) | 91,67% (=11/12) |

In short, we see that the game concepts are mentioned by a large proportion of the interviewees for both years. These results strengthen our reasoning that the game concepts are present in the decision-making processes. Therefore, it makes sense to interpret the case description with those game concepts. Fig. 1 gives an overview of the main differences between the game concepts in the two years. The boxes on top represent the first year, and the boxes below represent the second year. Further explanation is given in the remainder of this section.

### 5.1. Multi-Issue game

As becomes clear from the case description in Section 4, the decision-making process involves multiple actors with different responsibilities regarding the railway system. Interdependencies between actors exist and they have different interests. During the decision-making process several new issues are introduced, hence the agenda is broadened. On the agenda potential pain and gain is present for every actor. The previous mentioned items indicate that the M-I game is present. Table 3 categorizes aspects of the M-I game that contribute to the outcome of the decisions.

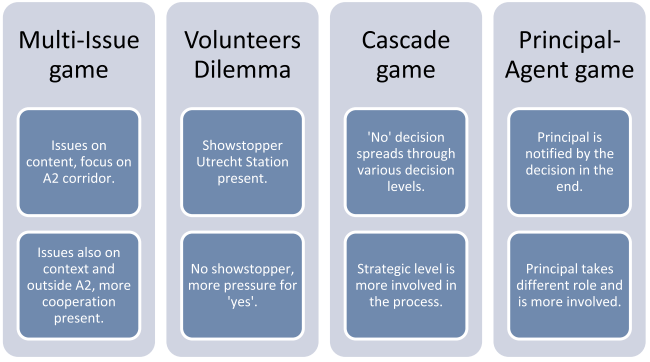


**Fig. 1.** Main differences between game concepts in 2015 (top) and 2016 (bottom).

**Table 3**
Multi-Issue game.

| Decision 2015: “no” | Decision 2016: “yes” |
|---|---|
| *Room for ‘no’ is created* | *Room for ‘yes’ is created* |
| Uncertainty, analysis of performance levels and the implementation of Flow Through Station Utrecht (DSSU). | MIE is willing to utilize the space available within contracts regarding the performance level. |
| *Linking of issues* | *Linking of issues* |
| Happens mainly inside A2 corridor. | Happens also outside A2 corridor. |
| *Incentives for cooperation* | *Incentives for cooperation* |
| One example of a part of the system that is not ready is sufficient to conclude that the entire system will not improve, thus cooperation is less necessary. | Cooperation is necessary since issues arise at the boundaries of responsibilities and the only way to handle them is by cooperation between actors. |
| *Type of issues* | *Type of issues* |
| Content issues are more important. | Context issues are more important. |

### 5.2. Volunteers Dilemma

The case study includes multiple actors with separate responsibilities. When the deadline for the decision is near pressure to take a decision increases. The uncertainty about the overall improvement of the performance level and analysis of the situation leads to more pressure. As a result, decision-makers start to perform wait-and-see behaviour and individual balancing of the different options occurs. Hence, the VD is activated. Table 4 differentiates the aspects of the VD according to the outcomes of the decisions.

### 5.3. Cascade game

A sequence of advices and decisions at different decision levels across organizations is executed before the final decision is taken. The output of one level provides the input for the next decision level. The actors of the different levels have knowledge about a specific part of the system and thus regarding the decision. Moreover, the decision space is limited. The elements discussed before indicate that the CG is activated. Table 5 identifies the aspects of the CG that separate the outcomes of the decisions.

### 5.4. Principal-Agent game

ProRail and NS together are the agent with operational knowledge regarding the system. MIE is the principal with little operational knowledge and is interested in more trains. The super-principal is the Parliament since MIE has to justify the outcome of the decision to the Parliament. The before mentioned elements indicate that the P-A game is activated. Table 6 presents the aspects of the P-A game that distinguish the outcome.

The game concepts provide a structure to compare the two decision-making processes. In particular it illustrates the actor and context dynamics present in the process. A different play of the game, or a different constitution of the elements of the game, contributes to an explanation for the different outcomes of the decision-making processes.

**Table 4**
Volunteers dilemma.

| Decision 2015: "no" | Decision 2016: "yes" |
|---|---|
| *Pressure* from a deadline, culture of organizations, uncertainty about overall performance of the system.<br>*Individual balancing* and predicting individual chance of failure. No one is expected to say 'no'.<br>VD is activated by the *showstopper* implementation of Utrecht Station at operational level. | *Pressure* from a deadline, uncertainty about overall performance of the system and burdens of the past.<br>*Individual balancing* less necessary since issues are solved in collaboration, more openness in the process and trust between decision-makers exists.<br>VD is not activated, *no showstopper* identified. |

**Table 5**
Cascade game.

| Decision 2015: "no" | Decision 2016: "yes" |
|---|---|
| *Sequence of decisions* known late in the process. This results in a conflict.<br>*Decision made by* operational decision-makers, the 'no' advice spreads through the different decision levels.<br>*(Private) information*<br>All information is present for the decision-makers. | *Sequence of decisions* known early in the process, hence there are no conflicts.<br>*Decision made by* NS in the end, the 'yes' advice is adopted on each decision level. The strategic level is involved in the process because of the burden of the past. Moreover, new decision-makers want to know the details.<br>*(Private) information*<br>More information is present since more analysis of issues is performed. |

## 6. Conclusion

In this paper we explain the differences between two decision-making processes using a limited set of game concepts. Identification of the game concepts in both processes is context dependent. However, both inductively (from case description) as deductively (from interview transcriptions), the same game concepts are recognized. Despite the fact that the same decision-making processes are performed in the first and in the second year, the outcomes are different. During interviews, conducted with decision-makers involved in the process, no major differences between both processes were reported. At first sight the processes are thus not that different. Looking from a technical perspective, in both cases, the desired improvement of the performance level is not visible at the moment of decision-making. Checking the boundary conditions for both processes would have let to the same outcome. Standard decision-based models which focus on technical/quantitative criteria are unable to show the difference between both processes. The approach of this paper gives an explanation why the outcomes are different and reduces the complexity of the process to the essence. As illustrated by the games being played differently in the first and the second year, the game concepts reveal the hidden actor and context dynamics of the decision-making process. The main observations of the analysis are summarized hereafter.

The role of MIE changes during the process and therefore the P-A game is played differently. In the second year, they become involved earlier in the decision-making process and take part of the decision for their responsibility. Moreover, a second P-A game, in which case MIE is the agent and the Parliament is the principal, becomes visible in the second year. Another argument explaining why the P-A game occurs different in the second year is that the negative decision of the first year serves as a burden of the past. In both years the same type of arguments, such as overpromise, under deliver and reputation are made, however, the second time, the arguments made previously are still in mind.

Complex issues are present in both decision-making processes. However, in the second year these issues are addressed more thoroughly, especially concerning issues at boundaries of responsibilities and sub systems. Decision-makers realize that cooperation between different parts of the organizations is necessary to reach the desired outcome. Pressure from strategic level contributes to this. It shows that the Multi-Issue game is more present and is played in a broader sense in the second year. The non-existence of a concrete showstopper in the second year, like the implementation of new station Utrecht in the first year, and the fact that more cooperation between different departments of the organizations takes place contribute to the Volunteers Dilemma not being expressed explicitly in the second year.

The non-existence of a 'volunteer' results in the Cascade game starting at a different point in the second year. In addition, compared to the first year, new actors arrive with different background which leads to the strategic level being more involved. As a result the spread of decisions, from operational to strategic level, occurs less easily explaining the development of the Cascade game.

The abovementioned list contains the main elements that contribute to a different outcome in the two decision-making processes. It indicates how the elements explain a different play of the game, or the game not being played at all. In short, the Multi-Issue game is more external oriented in the second year resulting in more room for another decision. In addition, due to the decision taken in the first year, the pressure to take a positive decision increases in the second year. As a

**Table 6**
Principal-Agent game.

| Decision 2015: "no" | Decision 2016: "yes" |
|---|---|
| *Burden of the past* is not explicitly present, however, since the railway sector has a culture of deciding 'yes' this is what the principal (MIE) expects.<br>*The outcome*<br>The principal is confronted with the decision of the agent after the decision has been taken.<br>*Asymmetric information*<br>The principal is unaware of the discussion and arguments prior to the decision. | *Burden of the past* is present since, in 2015, the agent (ProRail & NS) promises a 'yes' outcome to the principal (MIE). The principal has a burden of the past since they promise 'yes' to the super-principal (Parliament).<br>*The outcome*<br>The principal is involved in the decision-making process and even takes a part of the decision for their responsibility.<br>*Asymmetric information*<br>The principal knows the issues that arise during the decision-making process. |

consequence, the Volunteers Dilemma is not activated, meaning that no volunteer steps forward, and the cascade is not activated as such. Comparing this to the first year, we observe a shift in the Principal-Agent relationships which influences the Principal-Agent game. More room for another decision together with more urgency leads to a different decision.

## 7. Discussion and future work

The selection of the four game concepts is based on a theoretical link and our experience with complex decision-making processes. The identification of other relevant game concepts is an interesting direction for further research that could enrich the comparison of the decision-making processes. Furthermore, a limitation of our method is the subjectivity of scoring the interview transcriptions that could be solved by cross-checking the results with different researchers. An additional method to validate the results is to ask decision-makers involved to identify the game concepts in the process themselves.

The application of the game concepts to other processes is a direction for future research. The case study introduced is a unique process for the Dutch railways because of the joint preparation and actual decision-making of ProRail and NS. It would be interesting to compare the process and the identified game concepts with other decision-making processes within the transportation sector that deal with the same type of decisions.

In general, game theoretical models are prescriptive, meaning that they tell which constellation of actions leads to which (optimal) outcome of the game. The game concepts of this paper have this prescriptive nature as well. Therefore, it could give decision-makers action perspective to steer the process in a certain direction. We designed a recognition tool for decision-makers to identify game concepts during a decision-making process. The aim of the tool is to provide decision-makers with an actor and context perspective on the decision-making process, rather than an solely technical perspective. They become aware of the dynamics of the process and it could help them to avoid pitfalls, foresee risk and define actions to mitigate these risks. Moreover, it could assist them in foreseeing different possible outcomes of the process under different circumstances. For further research we currently test the tool with stakeholders involved in various decision-making process of the Dutch railway sector. This connects with research on learning and decision-makers being ‘reflective practitioners’. Further investigation of the connection between learning over time and the use of game concepts could be interesting.

Apart from this method being useful for decision-makers it has applications in academia. To our knowledge this is a new approach to characterize and analyse decision-making process in complex systems. It is based on existing theories from economics/mathematics (game theory) and public administration, and we aim to provide bridges between those disciplines and apply this to real-world cases.

## Acknowledgements

We especially thank the reviewers for their valuable contributions and their inputs have very much helped to improve the paper. This research is funded through the Railway Gaming Suite 2 program, a joint project by the Dutch infrastructure manager (ProRail) and Delft University of Technology.

## References

Ackhoff, R. L., Davis, P., Delesie, L., Ducamp, A., Emshoff, J. R., Hall, J., et al. (1969). *Conflicts and their escalation: Metagame analysis.* Managment Science center, University of Pennsylvania.

Adler, N., Fu, X., Oum, T. H., & Yu, C. (2014). Air transport liberalization and airport slot allocation: The case of the Northeast Asian transport market. *Transportation Research Part A: Policy and Practice, 62*, 3–19.

Adler, N., Pels, E., & Nash, C. (2010). High-speed rail and air transport competition: Game engineering as tool for cost-benefit analysis. *Transportation Research Part B: Methodological, 44*(7), 812–833.

Anderson, L. R., & Holt, C. A. (1996). Classroom Games: Information cascades. *The Journal of Economic Perspectives, 10*(4), 187–193.

Archetti, M. (2009). Cooperation as a Volunteer's dilemma and the strategy of conflict in public goods games. *Journal of Evolutionary Biology, 22*, 2192–2200.

Bekius, F. A., de Bruijn, H., Cunnighmam, S. W., & Meijer, S. (2016). Structuring the multi-issue and hub-spoke games found in public administration. *PICMET 2016, portland international conference for management of engineering and Technology*. IEEE.

Bennett, P. G. (1977). Toward a theory of hypergames. *Omega, 5*(6), 749–751.

Bennett, P. G. (1987). Beyond game theory –where? In P. G. Bennett (Ed.). *Ana-lysing conflict and its Resolution: Some mathematical contributions* (pp. 43–70). Oxford: Clarendon Press.

Bikhchandani, S., Hirshlleifer, D., & Welch, I. (1992). A theory of fads, fashion, custom, and cultural change as informational cascades. *Journal of Political Economy, 100*(2), 992–1026.

Binmore, K. G. (1987). Why game theory “doesn't work. In P. G. Bennett (Ed.). *Analysing conflict and its Resolution: Some mathematical contributions* (pp. 23–42). Oxford: Clarendon Press.

Brams, S. J. (1994). *Theory of moves.* Cambridge: Cambridge University Press.

Braun, D., & Guston, D. (2003). Principal-agent theory and research Policy: An introduction. *Science and Public Policy, 30*, 302–308.

de Bruijn, H., & Herder, P. M. (2009). System and actor perspectives on sociotechnical systems. *IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, 39*(5), 981–992.

de Bruijn, H., & Heuvelhof, E. (2002). Policy analysis and decision making in a network: How to improve the quality of analysis and the impact on decision making. *Impact Assessment and Project Appraisal, 20*(4), 232–242.

de Bruijn, H., & ten Heuvelhof, E. (2008). *Management in networks: On multi-actor decision making.* Taylor & Amp; Francis Ltd.

Cantarelli, C. C., Chorus, C. G., & Cunningham, S. W. (2013). Explaining cost overruns of large-scale transportation infrastructure projects using a signalling game. *Transportmetrica: Transportation Science, 9*(3), 239–258.

Coleman, J. S. (1972). Systems of social exchange. *Journal of Mathematical Sociology, 2*, 145–163.

Cunningham, S., Hermans, L., & Slinger, J. (2014). A review and participatory extension of game structuring methods. *EURO J Decis Process, 2*(3), 173–193.

Diekmann, A. (1985). Volunteer's dilemma. *Journal of Conflict Resolution, 29*(4), 605–610.

Dodgson, J., Spackman, M., Pearman, A., & Phillips, L. (2009). *Multi-criteria analysis: A manual. London*.

Easley, D., & Kleinberg, J. (2010). Information cascades. *Networks, crowds, and Markets: Reasoning about a highly connected world*. Cambridge University Press.

Fraser, N. M., & Hipel, K. W. (1984). *Conflict analysis: Models and resolutions.* New York: North-Holland.

Gehlbach, S. (2006). A formal model of exit and voice. *Rationality and Society, 18*(4), 395–418.

Gintis, H. (2000). Bosses and workers, landlords and peasants, and other principal-agent models. *Game theory evolving: A problem-centered introduction to modeling strategic behavior* (pp. 357–369). Princeton University Press.

Goeree, J. K., & Holt, C. A. (2000). An explanation of anomalous behaviour in binary-choice Games: Entry, voting, public goods and the volunteers' dilemma. *Virginia economics online papers. University of Virginia, department of economics*.

Hollander, Y., & Prashker, J. N. (2006). The applicability of non-cooperative game theory in transport analysis. *Transportation, 33*(5), 481–496.

Ishizaka, A., & Nemery, P. (2013). *Multi-criteria decision analysis: Methods and software.* John Wiley & Sons.

de Jong, S., Tuyls, K., & Verbeeck, K. (2008). Fairness in multi-agent systems. *The Knowledge Engineering Review, 23*(2), 153–180.

Klijn, E. H., & Teismand, G. R. (1997). Strategies and games in networks. In W. Kickert, E. H. Klijn, & J. Koppenjan (Eds.). *Managing complex networks* (pp. 98–118). SAGE Publications Ltd.

Koppenjan, J., & Klijn, E. H. (2004). *Managing uncertainties in networks.* Taylor & Amp; Francis Ltd.

Koppenjan, J., Veeneman, W., Voort, H., van der, H., ten, E., & Leijten, M. (2011). Competing management approaches in large engineering projects: The Dutch RandstadRail project. *International Journal of Project Management, 29*(6), 740–750.

Laffont, J.-J., & Martimort, D. (2002). *The theory of incentives: The principal-agent model.* Princeton and Oxford: Princeton University Press.

Morrow, J. D. (1994). *Game theory for political scientists.* Princeton, New Jersey: Princeton University Press.

Mozafari, M., & Karimi, B. (2011). Pricing for freight carriers in a competitive environment: A game theory approach. *International Journal of Industrial Engineering Computations, 2*(3), 467–478.

Nikas, A., Doukas, H., & Martínez López, L. (2018). A group decision making tool for assessing climate policy risks against multiple criteria. *Heliyon, 4*(3).

Oruç, S., & Cunningham, S. W. (2014). Game-like characteristic of engineering design. *Infranomics, Springer, 24*, 257–266.

Rasmusen, E. (2007). *Games and Information: An introduction to game theory.* Malden: MA: Blackwell Publishing.

Rosenhead, J., & Mingers, J. (2001). *Rational analysis for a problematic world Revisited: Problem structuring methods for complexity, uncertainty and conflict, Wiley, Chichester, 2001, xvi.* Chichester: Wiley.

Sebenius, J. K. (1983). Negotiation arithmetic: Adding and subtracting issues and parties. *International Organization, 37*(2), 281–316.

Slinger, J. H., Cunningham, S. W., Hermans, L. M., Linnane, S. M., & Palmer, C. G. (2014). A game-structuring approach applied to estuary management in South Africa. *EURO Journal on Decision Processes, 2*(3–4), 341–363.

Stauvermann, P. J. (2004). Application of principle-agent models in science policy.

*Comparative perspectives on scientific expertise for public policy* (pp. 1–13). .
Takebayashi, M. (2014). The future relations between air and rail transport in an island country. *Transportation Research Part A: Policy and Practice, 62*, 20–29.
Takebayashi, M. (2015). Multiple hub network and high-speed railway: Connectivity, gateway, and airport leakage. *Transportation Research Part A: Policy and Practice, 79*, 55–64.
Teisman, G. R., & Klijn, E. (2008). Complexity theory and public management. *Public Management Review, 10*(3), 287–297.
Tweede Kamer der Staten-Generaal (2015a). *Letter from department of infrastructure and environment to parliament*.
Tweede Kamer der Staten-Generaal (2015b). *Rapport parlementaire enquêtecommissie fyra*.
van de Velde, D. M., Jacobs, J., & Stefanski, M. (2009). Development of railway contracting for the national passenger rail services in The Netherlands. *International conference series on competition and ownership in land passenger transport – thredbo 11*.
Zahedi, F. (1986). The analytic Hierarchy process: A survey of the method and its applications. *Interfaces, 16*(4), 96–108.