10th International Conference on Through-life Engineering Service
16-17 November 2021, University of Twente, The Netherlands

Coordinating project complexities in inter-organizational railway projects – an operationalization of the complexity-response framework (Part I)

Nina Jakubeit[a]*, Jan Braaksma[a], Mohammad Rajabalinejad[a], Leo van Dongen[a]

[a]*Design, Production and Management Department, University of Twente, De Horst 2, Enschede 7522 LW, The Netherlands*

* Corresponding author. Tel.: +31 (0) 53 489 6864. *E-mail address:* n.jakubeit@utwente.nl

Abstract

Large-scale inter-organizational transportation projects play a critical role in the design and development of existing and new railway networks. However, in the past, inter-organizational projects have shown shortcomings in effective decision-making and system integration due to an unilateral use of coordination mechanisms. The goal of this work is to provide an operationalization of the complexity-response framework for the Dutch railway project context, thereby extending the coordination mechanisms currently considered.

To that end, we conducted design science research to operationalize the complexity-response framework based on an analysis of the specific inter-organization railway context, and evaluate its validity by means of follow-up discussions with project members.

The operationalization of the framework can be used to capture and evaluate the coordination mechanisms employed, and identify potential matching coordination responses to the assessed railway system project complexities at the outset of the project. Further research is needed to assess the fit between the coordination responses applied and those proposed.

Keywords: Design science research; Inter-organizational projects; Complexity-response framework; Coordination mechanism;

1. Introduction

Previous inter-organizational transportation projects have shown performance deficiencies due to the increasing complexity of coordinating these, especially when diverse stakeholders are involved in multiagency projects [2]. Furthermore, these transportation projects are responsible for improving and updating infrastructure, whose societal value is directly visible to the general population [3]. However, the social value created in projects becomes visible only after integration [4]. Artto, Ahola, and Vartiainen state that in order to achieve proper system integration in projects which involve multiple organizations, the complexity and dynamics within them increase [4]. Additionally, decisions in inter-organizational transportation projects involve a large number of stakeholders from different organizations, whose interests do not always align [5]. As a result, decision-making is often more conflictual than in intra-organizational projects [6] which adds complexity to decision-making in inter-organizational projects.

Understanding how to manage these complexities forms the basis for responding to them [7]. Building on the need to establish contingency approaches to project management [8], Maylor and Turner developed the so-called complexity-response framework (CRF) to aid in understanding project complexities and trigger appropriate coordination mechanisms by means of targeted responses, which enable coordination [1]. Their assumption is that no single type of project management approach addresses all complexities equally well, but rather than casting a wide net, a more focused approach is needed. This is consistent with other literature (e.g. [9]) which observes a mismatch between the commonly desired focus on planning & control and the flexibility required to deal with uncertainty.

Particularly in technical and engineering-driven fields, such as transportation, the literature observes a dominant focus on planning and control responses [9], which have also shaped the project management field during the last years [10]. However, given the increasing complexity of inter-organizational projects, planning and control measures may not always be the most appropriate approach in such an environment, especially due to the need to manage different interests in joint decision-making [6]. Research on identifying different coordination responses addressing distinct project complexities [1]has been conducted. The authors are not aware of an application of the framework in the context of system integration and joint decision-making. To investigate this, we conducted design science research

Peer-review under responsibility of the Programme Chair of the 10th International Conference on Through-life Engineering Services.

to operationalize the CRF and test it in the context of the Dutch railway system.

This paper is organized as follows: First, an overview of project complexity and coordination mechanisms is provided, and the design science research methodology is introduced. Thereafter, the results of the operationalization are presented. In the discussion which follows, the applicability of the CRF for inter-organizational railway projects is evaluated, and finally, suggestions for future research are offered.

2. Coordination of inter-organizational projects

2.1. *Inter-organizational transportation projects*

Transportation projects have several characteristics which make them an interesting starting point for research. On the one hand, the outcomes of transportation projects, such as major infrastructure improvements, are visible to the general public. Consequently, this leads to increased social interest of such transportation projects [1, 3]. On the other hand, these major transportation projects often result in performance shortcomings that leads to societal dissatisfaction. The reasons for these inadequacies are not well understood [11]. One possible explanation is offered by Flyvberg's performance paradox [2], which states that the importance of projects often contrasts with their performance. According to Maylor and Turner, increasing complexity is cited as a possible explanation for this lack of performance [1].

2.2. Complexities of inter-organizational projects

There are two important factors that contribute to the increased complexity of inter-organizational transportation projects, these are the need for system integration, and coordinated decision-making. Firstly, the need for system integration arises because transportation projects are often undertaken in an environment involving multiple interdependent organizations which can only create value together. This is described by Davies, who characterizes a continuous value creation process between multiple organizations, beginning in the project phase and continuing through the operations phase [12]. Artto, Ahola, and Vartiainen consider this system lifecycle view to be critical to system integration [4], which means the work of these organizations must be integrated to create shared value for operations. Viewing the system lifecycle view through a complexity lens, in cases where multiple organizations collaborate to achieve system integration, complexity appears to increase. Secondly, coordinated decision-making in multi-organizational projects is complicated by the fact that it affects a large number of different stakeholders across organizational boundaries, and their respective interests are not always perfectly aligned [5]. This misalignment can lead to conflict among the various stakeholders. Similarly, van Marrewijk, Ybema, Smits, Clegg, and Pitsis [6] state that inter-organizational decision-making is more prone to conflicts. Based on this view of conflict and shifting interests, the setting of inter-organizational decision-making appears to be more complex than intra-organizational decision-making.

Inter-organizational transportation projects exhibit a high degree of variation in complexities, e.g. socio-political complexities: the dynamics of these complexities require specific coordination [1].

2.3. Coordinating inter-organizational project complexities

As stated above, various complexities are present in inter-organizational transportation projects. These complexities can be addressed by means of appropriate coordination responses [1]. Commonly, there is a natural desire to address complexity in projects by means of planning and control responses, which can be explained by Thompson's coordination mechanisms [13]. Johnson, for example, argues that technical complexity and novelty were important drivers for the establishment of project management as an activity in the twentieth century, which heavily relies on the coordination mechanism of planning and control [14]. Furthermore, Koppenjan, Veeneman, Van der Voort, Ten Heuvelhof, and Leijten demonstrate that for coordination in projects, planning and control is often a strong focus, especially when it comes to managing risks [9]. Additionally, for system projects, the focus on work breakdown structures constitutes one of the most commonly used tools in project management [15], and is part of the planning and control coordination responses. Although empirically there is a strong focus on planning & control activities, there are also arguments in favor of a more nuanced view of project coordination. For instance, Koppenjan et al. demonstrate that in large engineering projects, tension exists between the desired focus on planning and control, and the requirement to remain flexible in the face of task uncertainty [9]. Liu and Leitner conclude that managers respond to complexity by being ambidextrous in their approaches – using both strategies of exploitation (applying known or planned responses) and exploration [16]. Finally, Staadt addresses the complexity related to reciprocal incomprehension in projects that can be addressed by means of soft systems methodology [17].

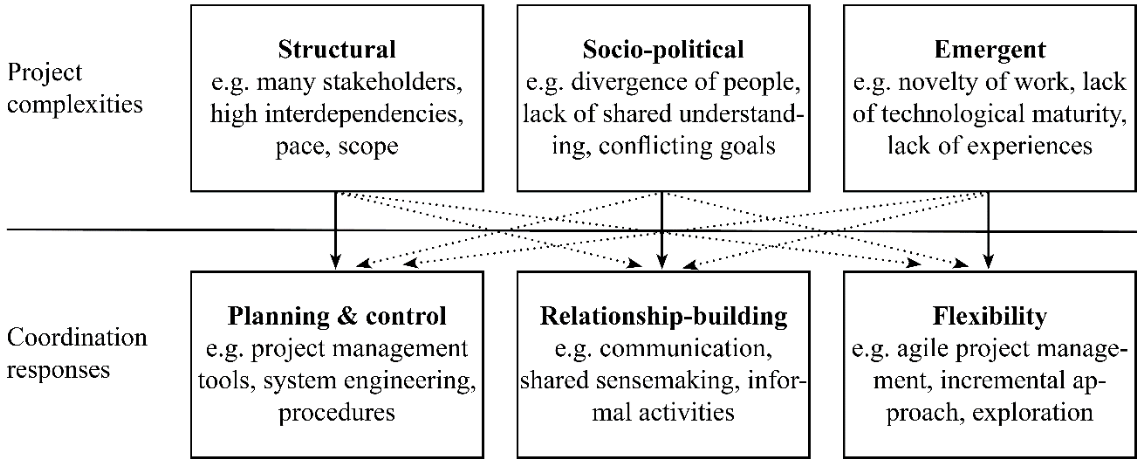

Fig. 1. The complexity-response framework, amended from [1]

Maylor & Turner developed a contingency approach for dealing with project complexity [1]. The so-called complexity-response framework (Fig. 1) distinguishes between three different types of complexities. These dynamic complexities pose unique challenges due to their variable nature, as they can consist of structural (e.g., interdependencies), socio-political (e.g., people), and emergent (e.g., uncertainties) elements [18, 19]. For each of these complexity elements, the authors identify a preferred coordination response. Structural complexity is characterized by scope, interdependence, and speed. Its responses are shaped by project management tools [20] and can be described as "planning and control" responses. Socio-political complexity, defined by conflict, politics, and lack of mutual understanding, seeks an approach that builds relationships between people, especially in conflict-laden cases [21]. Relational coordination requires increased communication efforts or shared sensemaking activities. Finally, emergent complexity, characterized by elements of novelty, uncertainty, and lack of experience, can be addressed with flexibility. Examples of flexibility include agile project management and working with SCRUM [22]. Maylor & Turner also note that other coordination responses can be used to address complexities [1].

To summarize, the relevant literature suggests that in technical environments, such as transportation projects, the focus is generally placed on coordination by means of planning and control. Operationalizing and applying the CRF to the railway system context can potentially provide these specific technical environments with a more nuanced tool that helps them to identify other coordination mechanisms. To date, most research has focused on establishing the contingency approach. However, we have limited data on the practical applicability of the framework in environments such as the railway system.

3. Research Design and Methodology

This paper uses the design science research methodology (DSR) which results in an “artifact created to address an important organizational problem” [23]. This entails a research process which employs both theoretical and empirical knowledge in order to find a solution to the defined problem. In addition to designing the artifact, another important process step is the evaluation of the artifact in the chosen context in order to verify that it is a valid solution to the problem [23]. As such, DSR starts by outlining a relevant research problem and culminates in a design that is operationalized and evaluated in a non-theoretical context [24], see Fig. 2.

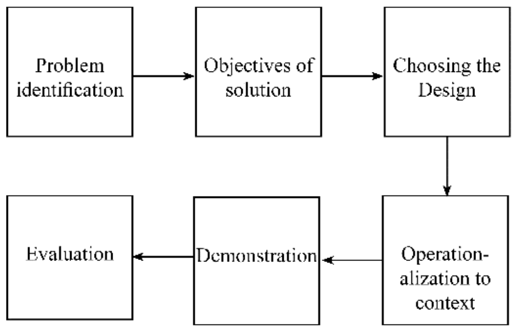

Fig. 2. Design science research process, adapted from Peffers [24].

3.1. Problem identification

In the literature review, it became apparent that in technical environments, such as that of a railway system, coordination in cross-organizational projects often has a unilateral focus, while project complexities suggest the use of more sophisticated coordination mechanisms. It seems that project members may be unaware of the available options regarding coordination responses, or their intended use.

3.2. Objectives of the solution

The objectives of the solution are threefold: concerning the developed method itself, the results of the method and the usability of the method.

- The method should assist project members in choosing appropriate coordination actions to manage project complexities. Such a method should build on the uncertainties of the project environment to better inform coordination decisions.
- The results of the method should highlight positive aspects of the current coordination methods, as well as suggest areas for improvement. This will ensure that responses which are already working well are not disadvantaged and that the focus for improvement is on the right aspects.
- The usability of the method should provide a reference point for the individual project members. It is important that it is easy to use in practice and that it incorporates the language of the railway system.

3.3. Choosing the design

The project complexity literature is used to identify appropriate responses to the complexities (paragraph 2.3). The CRF brings the various complexities under one umbrella, and guides the search for appropriate coordination mechanisms. The CRF is expanded on by adding two important aspects to the original framework. Firstly, the *coordination response* part of the framework is improved by distinguishing between coordination activities that are positive and those that need improvement. In this way, the appropriate coordination for each project context can be identified. Secondly, an additional level of detail is added to the framework to better represent the complexity experienced and the coordination responses applied. This aligns the responses mentioned by Maylor & Turner [1] more specifically to the railway context. The responses identified are derived from interviews conducted with our expert-group of rail project members. As a result, they are better adapted to the language of the railway system.

3.4. Operationalization to context

The complexity-response framework was operationalized for the railway system context. Additional context-specific complexities and coordination responses were identified in the case studies through semi-structured interviews with railway project experts. First, the *complexities* were operationalized using Maylor & Turner's [1] categories, with an additional (third context-specific) level of detail added (see Table 1 for the additional sub-categories from the case studies). For the added sub-categories, the codes associated with each sub-category are reported (Table1). *Coordination responses* were then operationalized in a similar manner (Table 2) categorizing either 1) positively perceived coordination responses or 2) proposed improvements to coordination responses. The codes were defined based on what our expert-group, consisting of current and former senior project staff, perceived as project coordination working well and what they perceived as suggested improvements to project coordination.

4. Demonstration & evaluation

4.1. Demonstration of the complexity-response framework in two railway projects

The adapted CRF was applied in two inter-organizational railway projects of NS and ProRail. In both cases, information on project *complexity* and on *coordination responses* was collected in one-on-one interviews with the involved project members from NS and ProRail. Notes were taken on these conversations, which were then transcribed and verified with the respective interviewees from the expert-group. Subsequently, these transcripts were

Table 1. Complexities experienced in the Railway system.

Structural complexities	Socio-political complexities	Emergent complexities
Pace: Pressure on progress. Scope: Broad project, interfaces with many different organizational sub-structures. Interdependencies: Many interdependent stakeholders, not all well represented in the project.	Divergence of people involved: Different communication styles between decision-makers - project leads (informal vs. formal). Different organizational cultures. Lack of shared understanding: Different viewpoints at the start/during project. Different interests at the start/during project. Different perceptions regarding responsibilities. Lack of commitment: Disagreement regarding the actual problem. Unclear project ownership.	The novelty of work: New product raising uncertainties. Difficulties predicting the consequences of an action. Huge change impact of implementation (operational processes change). Unclear responsibilities due to new processes. Lack of previous experience: Limited supplier knowledge about a new product. Other changes imposed on the project: Team members & decision-makers change.

coded using AtlasTI to thematically sort and cluster the responses into the three different complexity categories (summarized in Table 1) and the three different coordination response categories (summarized in Table 2).

4.2. Evaluation of the complexity-response framework

The complexity table (Table 1) and the response table (Table 2) were presented to the project members in order to evaluate the results. The preliminary results of this evaluation show that the project members recognized the presented complexities. Additionally, project members confirmed the results of the CRF, which included both the proposed improvements and the positive coordination responses experienced. During the evaluation with project members, it was suggested that the framework should be used more at the start of the inter-organizational project in order to guide the use of coordination mechanisms. As such, the added value of this analysis was recognized. Furthermore, the project manager of the first project confirmed that she actually intended to use the coordination mechanisms identified in the framework, suggesting that the way responses were mapped correlated with the coordination mechanisms the project manager focused on in the project. All in all, the operationalization of the complexity-response framework for the context of the Dutch railway system seems to reflect the complexity and coordination mechanisms present in inter-organizational railway projects.

5. Conclusion

This paper observes that in technical environments, such as the railway system, there is often a unilateral coordination focus within projects. However, focusing on a specific coordination mechanism cannot address all experienced project complexities. To address this problem, the complexity-response framework was operationalized and applied to two railway system cases. The preliminary evaluation of the framework shows that the application of the CRF is well received in inter-organizational railway projects and seems to help project members achieve focused project coordination. Applying the CRF in the context of the railway system showed it can aid in identifying appropriate responses to the experienced project complexity. It was also demonstrated that it can create awareness of the use of the proposed coordination responses in the given environment. This is particularly relevant for alerting project members to the pitfalls of focusing too much on one-sided responses.

5.1. Future research suggestions

Having established that the CRF is strongly applicable to the context of the railway system, this provides opportunities for further study. Applying the framework to future railway system cases can help in assessing the "fit" between the complexities experienced and the coordination responses currently applied to deal with these complexities. In doing so, further conclusions can be drawn regarding (unintentional) overemphasis on a particular coordination mechanism and its consequences.

Table 2. Matched coordination responses with the complexities (* = positive response; ** = improvement response).

Coordination Responses	Structural complexities	Socio-political complexities	Emergent complexities
Planning & control	*Good preparation of complex issues; **Better planning of activities at the start; **Better capacity planning; **Better preparation of supplier; **Overview of follow-up tasks;	**Assign project lead at both companies; **Overview of decision-making; **More process agreements defined; **Better description of roles & responsibilities;	*Graphical notation structure in order to structure arguments for emergent issues; **Overview for coping with changes;
Relationship development	*Follow-up on highlighted issues; **Better scope definition at the start; **Better external communication; **Better representation of all parties;	*Transparency in the project team; *Team collaboration; *Project lead with overarching interests; **Develop more empathy & understanding;	*Short and informal communication lines;
Flexibility	*Embrace change from standard processes;	*Engage in joint updating sessions with major stakeholders;	*Test & learn approach; **More agile/scrum working;

References

[1] Maylor H, Turner N. Understand, reduce, respond: project complexity management theory and practice. International Journal of Operations & Production Management. 2017.

[2] Flyvbjerg B, Bruzelius N, Rothengatter W. Megaprojects and risk: An anatomy of ambition: Cambridge University Press; 2003.

[3] Flyvbjerg B. The Oxford handbook of megaproject management: Oxford University Press; 2017.

[4] Artto K, Ahola T, Vartiainen V. From the front end of projects to the back end of operations: Managing projects for value creation throughout the system lifecycle. International Journal of Project Management. 2016;34:258-70.

[5] Geyer A, Davies A. Managing project–system interfaces: case studies of railway projects in restructured UK and German markets. Research policy. 2000;29:991-1013.

[6] Van Marrewijk A, Ybema S, Smits K, Clegg S, Pitsis T. Clash of the titans: Temporal organizing and collaborative dynamics in the Panama Canal megaproject. Organization Studies. 2016;37:1745-69.

[7] Williams T. Assessing and moving on from the dominant project management discourse in the light of project overruns. IEEE Transactions on engineering management. 2005;52:497-508.

[8] Thomas J, Mengel T. Preparing project managers to deal with complexity–Advanced project management education. International Journal of Project Management. 2008;26:304-15.

[9] Koppenjan J, Veeneman W, Van der Voort H, Ten Heuvelhof E, Leijten M. Competing management approaches in large engineering projects: The Dutch RandstadRail project. International Journal of Project Management. 2011;29:740-50.

[10] Kapsali M. Equifinality in project management exploring causal complexity in projects. Systems Research and Behavioral Science. 2013;30:2-14.

[11] Lenfle S, Loch C. Has megaproject management lost its way. The Oxford handbook of megaproject management2016. p. 21.

[12] Davies A. Moving base into high-value integrated solutions: a value stream approach. Industrial and corporate change. 2004;13:727-56.

[13] Thompson JD. Organizations in action: Social science bases of administrative theory: Transaction publishers; 2003.

[14] Johnson SB. Technical and institutional factors in the emergence of project management. International Journal of Project Management. 2013;31:670-81.

[15] Morris PW. Reconstructing project management: John Wiley & Sons; 2013.

[16] Liu L, Leitner D. Simultaneous pursuit of innovation and efficiency in complex engineering projects—A study of the antecedents and impacts of ambidexterity in project teams. Project Management Journal. 2012;43:97-110.

[17] Staadt J. Redesigning a project‐oriented organization in a complex system: A soft systems methodology approach. International Journal of Managing Projects in Business. 2012.

[18] Maylor H, Meredith JR, Söderlund J, Browning T. Old theories, new contexts: extending operations management theories to projects. International Journal of Operations & Production Management. 2018.

[19] Geraldi J, Maylor H, Williams T. Now, let's make it really complex (complicated). International Journal of Operations & Production Management. 2011.

[20] Meredith JR, Shafer SM, Mantel Jr SJ. Project management: a strategic managerial approach: John Wiley & Sons; 2017.

[21] Park J-G, Lee J. Knowledge sharing in information systems development projects: Explicating the role of dependence and trust. International Journal of Project Management. 2014;32:153-65.

[22] Highsmith J. Agile project management: creating innovative products: Pearson education; 2009.

[23] Hevner, March, Park, Ram. Design Science in Information Systems Research. MIS Quarterly. 2004;28:75-.

[24] Peffers K, Tuunanen T, Rothenberger MA, Chatterjee S. A design science research methodology for information systems research. Journal of management information systems. 2007;24:45-77.