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Collaborative governance models towards sustainable infrastructure projects: the case of resources

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Abstract. The construction and infrastructure industry contribute to almost a quarter of global greenhouse gas emissions and is one of the largest drivers of resource use. This sector of the global economy is thus a promising area to look at for reducing environmental impact and increase sustainability. The impact of collaboration and cooperation within the project organisation has begun to garner more attention as the scale and scope, as well as the levels of uncertainty and complexity in construction and infrastructure projects have grown. This has led to an increase in collaborative contracting models applied to complex construction projects. In order to investigate the impact of collaborative contracting and the possibilities to advance the goal of resource efficiency and decrease environmental impact, a case study of two Nordic projects, utilising a collaborative project management model, is conducted. The findings suggest that the potential of using collaborative project management models in order to increase the sustainability of construction solutions is high. However, the use and understanding of the models vary between project actors. We conclude that the new collaborative project management models are important features in reducing environmental impact from infrastructure construction, yet several organisational and practical issues remain to be solved.

1. Introduction

With over 70 % of the world's population being predicted to live in urban areas by 2050 [1], the impact on urban planning, construction, and infrastructure projects is immense. As the construction sector is responsible for approximately 23 % of CO_2 emissions of the global economics activity [2], and as e.g. road construction is one of the largest drivers of resource use [3], the infrastructure sector is highlighted as especially interesting to study from the perspective of resource use and environmental impact. Even small gains in this sector can have major global consequences regarding sustainability and reaching the sustainable development goals as defined by the UN. "Sustainability" can be defined as using resources in a way that the resource in question isn't permanently damaged and can thus be utilised again in a future setting [4,5]. The goal of sustainability in an infrastructure construction context is twofold. First, the goal of minimising the effect an infrastructure construction project has on the existing environment, and second, the goal of managing the project in a way that minimises resource waste during the project execution phase, which is the focus of this study. Sustainability in an infrastructure project context would therefore indicate a project management model, which uses existing resources in a way that doesn't deplete them and keeps the resources in the system. It is increasingly important to manage infrastructure construction projects effectively to ensure resource efficiency throughout the process. Thus, a sustainably managed infrastructure project would help us achieve UN development goal number 9, in that it helps us develop reliable infrastructure of high quality, and increases resource-use efficiency.

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Construction and especially infrastructure projects are often complex [6], managed by people unaccustomed to such endeavours [7], have a noticeable impact on their environments [7], and involve several separate stakeholders or actors, comprising a network [8,9]. The actors involved in such complex construction projects have often different goals, as literature in both network theory and project management state [10,11]. The client, usually a public agency or organisation, has goals based on the public interest, while other actors like lead designers and the contractor usually are private enterprises, and as such are most focused on their own baseline profitability and performance [12]. In order to enhance collaboration between these different actors and stakeholders on a project, collaborative contracting models, such as alliances, early contractor involvement, integrated project delivery, and partnering, have been utilised in the last decades for complex infrastructure projects, taking the form of relational contracting or collaborative procurement in literature [12–14].

The relationships shaped in a collaborative project management model both enable and constrain the organisations and actors participating in the project, and thus their ability to realise their own goals with the project [10,15,16]. In order to further their own goals, project participants are utilising both their own resources, as well as the resources of others in the project [10]. In an infrastructure construction context, these resources might include industry-specific knowledge, processes, document templates and IT-systems.

The collaborative project models highlight an early inclusion of all key stakeholders in the project, a collaborative culture, administrative consistency, and commercial unity [14]. Much of the current literature in the field has focused on the contractual aspects, as well as well as delivery methods [17]. These new management models have demonstrated benefits related to project output [18–21], but there is little known about how the different actors of such a network collaborate and how such a collaborative governance model impacts the use of resources towards sustainable infrastructure project management.

The aim of this paper is to examine the impact of collaborative project management models on infrastructure construction and resource utilisation through a case study of two infrastructure construction projects in a Nordic context.

2. Collaborative project networks, roles, and resources

A project can be defined as a network, connected by ties between actors, sharing resources and partaking in actions or activities [10]. In an infrastructure project, the actors are the organisations participating in the project, resources are both tangible and intangible, and activities are both activities related to design and construction, but also activities related to the project organisation, such as meetings. Ties within the network enable resource sharing and collaboration, as a high relation of ties to actors enable sharing especially intangible resources between network actors [10]. The ties connecting the nodes in a network can be e.g. contractual relations, meetings, or project management processes. One of the strongest ties lies in the contract that forms the base of the project and defines both project processes and project outcome [13]. This contract can be seen as both a restraint, but also and driver of innovation and resource utilisation.

In this paper, a project is perceived as a network connected by ties between actors, sharing resources and executing actions [10]. Coordination among actors of such a network becomes especially challenging for large and complex infrastructure projects, which are known to suffer from excessive cost overruns [22], adversarial relationships and fragmentation [12,21,23,24] as well as unpredictable outcomes in terms of schedule and budget [13,22]. As the projects characterising the construction industry grow larger, both in terms of scope and scale, their organisational structure becomes ever more complex and the risks inherent in them grow as well [8,10,22].

During the last two decades, collaborative project management models have garnered attention in the construction industry due to the potential they have shown in improving project outcomes for all parties involved [12,13,25]. The benefits of such models are well documented in literature, and range from better risk management, integrating the constructor's knowledge in an early project phase, improving innovation and efficiency within the project, to reducing delivery times, and efficient resource utilisation [8,14,21,23,24]. A factor little explored in literature is how the client role, shaped

by the current industry frameworks of adversity and strife, is changing when adapting new project models. Another aspect, especially relevant in this article, is how efficient resource utilisation, an identified benefit of collaboratie project models, shapes sustainable project governance.

An increasingly important part in procurement processes and construction decisions have been the focus on environmental aspects and resource efficiency [26–28]. Resource efficiency can be seen as the efficient use of both tangible as well as intangible resources, which are both used in infrastructure projects [29]. In business literature, resources are often divided into assets, which can be both tangible and intangible, and capabilities, which are organisation-specific and shaped by the organisation's context [30]. There is little debate on the definition of tangible resources in general discourse, while intangible resources are harder to define and thus harder to discuss [30,31]. Tangible, or physical, resources in infrastructure projects are e.g. equipment, construction materials, and software. Intangible resources are e.g. knowledge regarding project execution or processes related to it, or financial instruments [29]. As the field of tangible resources, commonly defined as production, hasn't seen a major improvement over the last decades and there is an estimated global savings potential of US$0,6 trillion in the project management phase, by streamlining delivery and improving project selection [32], there is therefore a major potential for improved resource efficiency if the areas of project management and procurement can be improved. In the setting of sustainable infrastructure construction projects, a focus on intangible resources, which can include knowledge of eco-friendly design solutions, effective construction process management, or a project management method that minimises delays in the construction process, can therefore be of consequence. We focus in this article on the concept of project management.

3. Method

In order to fulfil the objectives of this study we studied two large and complex infrastructural projects, where document analysis and interviews were carried out. The two case studies represented two Nordic infrastructure construction projects, implemented in an urban setting and employing a collaborative project management approach. Case one is a large-scale infrastructure construction project, constructing a new public transportation setting based on rail, where the public client and the contractor have a bilateral contract, with the contractor subcontracting planning and other aspects of project execution. Case two is a large-scale infrastructure construction project, constructing a new public transportation setting based on light rail, where the public client, the contractor, and the planner (consultant) all are part of the same contract (multi-party contract). Both projects employed a two-step process, where a design phase was followed by a client decision on whether to continue with construction or end the project. Both projects were greenlighted by the client and are currently under construction. The projects are applying different collaborative project management models and are performed in different countries which makes it difficult to generalise findings. However, the differences in the cases help us highlight variances between the models, as the cases are comparable in both size and cultural framework surrounding the project setting. Semi-structured interviews were conducted, both on all levels of project organisation, as well as in the three segments of client, lead designer, and contractor. A total of 40 interviews were conducted (20 interviews for case 1 and 21 interviews for case 2), and all interviews were taped and transcribed. For the analysis, we thematically coded the interviews in relation to network relations, actors and how they collaborate in the project network.

4. Findings

The main findings relate to the client's role; the perceived benefits associated with the model, such as time savings and a reduction in resource use; and the impact of the contract on the project as well as the environment. The findings are summarised in table 1.

Client's role

Both cases were the first large-scale application of a collaborative project management model in their respective fields, which has brought with it both complications and teachings for the future, especially

related to the client's role in a collaborative project setting. In one case, the roles were more in line with traditional project delivery models, while the other case had adapted their project organisation to the requirements placed on them by the collaborative model employed. But both cases showed a clear change in the client role, due to the collaborative model. As one respondent states, "what's special about this is, that this is a very complex and unusual situation, as this [project management] model is new to [the clients], […] and the model affects specifically the role of the client. And in my opinion, this is, maybe, the biggest lesson in this model, relating to the role of the client". This active and involved client role was something novel to the respondents in both cases, and although there were some differences in how involved the client was, there were clear benefits identified in both cases by respondents from all actors.

Active client participation and engagement in early phases of the project were seen to have a strong impact on both scheduling and resource use, as successful collaboration was perceived to enable more resource-efficient work streams. Contractors and planning consultants are used to both project work and working together with different actors, but this was not something that the client was seen to be experienced in: both the contractor party as well as the client party discussed that the role of the client was changing in such a collaborative project model and that from the interviews it became clear that this role is not fully clear yet and needs further development, with focus on their active involvement in the early phases of the project. A lack of human resources from the client was seen as a hindrance in early phases of the project and impacting both design and construction. A more involved and active client in early phases of a collaborative project was seen as a positive factor, especially as this could lead to less bureaucracy in the planning and decision-making phase.

Perceived benefits

Even though the application of the collaborative project management model was new, both cases highlighted several perceived benefits of the model. The main benefit was tied to the early inclusion of contractor knowledge in the project, as this was perceived to ease design efforts as well as make the construction phase more efficient, due to the input attained from contractors in the design process. The main advantage of this inclusion was related to time savings: respondents in case one were confident in keeping the planned schedule, which is uncommon in infrastructure construction, while respondents in case two were anticipating significant time savings at the end of the construction phase. The working collaboration between all involved actors was seen as highly positive especially in the urban environment of the infrastructure being build. "Especially as you build in an existing environment, you can never be sure what previous contractors have done", as one respondent put it, discussing the multi-layered reality of building in an urban environment. The collaboration between all actors expediated the decision-making process and the design planning was seen as an iterative activity included in the project, rather than a finished product to be redone at the project's expense. Time and resource savings were also expected due to this. There was, however, some imbalance related to the collaboration between lead designers and contractors. As the reality of a construction site is uncertain until you have begun the construction process, a working balance between finished design planning and the construction process was hard to ascertain. The lack of a clear finish-line for design was seen as a problem in case two, as it prevented the project from both utilising economies of scope and scale as well as interconnected material flows, due to an asynchronous project execution, and thus minimising environmental impact from both procurement as well as transport of material. There was, for example, an early initiative to repurpose gravel and other by-products of preparatory demolition works, which was abandoned as other construction sites in the project became out of phase. This would have lowered the construction costs as well as the environmental impact, although the respondent could not quantify their assumption.

Contractual aspects

The biggest difference between the cases could be found in the contract and how it shaped the project. In case one, the client had a bilateral contract with the contractor subcontracting the design planning. Case two employed a multi-party contract. In case one, the actors disagreed on the interpretation of the

contract, with the client having a distinctly different perspective than the contractor, resulting in managerial and administrative rifts. This became especially clear as the project entered the construction phase, and differences between client's and contractor's understanding of the contract became highlighted by demands in the construction process. The client saw the project, both design and construction, as a collaborative whole, employing a standard contract form, while the contractor perceived the phases of design and construction as separate projects, governed by their respective contracts. In case two, the contract and its appendices was seen as one of the best parts of the project organisation: a flexible enabler that made collaboration possible and enabled the actors to "only focus on technical problem solving" instead of interorganisational disputes.

A somewhat surprising finding related to contracts was the impact of environmental requirements included in the contract – especially in project one. Representatives for both contractor and client in case one mentioned the importance of environmental requirements in the contract and commented on how this heightened the possibility for innovation, as it pushed the project to consider unorthodox solutions to solve the requirements, such as new, more efficient machinery to minimise noise due to strict noise levels set forth in environmental requirements. As the requirements often come from local and national governments and regulatory bodies, respondents from both cases highlighted the need for the client to communicate with regulatory bodies, such as ministries and environmental agencies, to ensure a sufficient level of environmental requirements in the project. This was seen as tied to the importance of the client's role in the project, as their involvement contributes to beneficial environmental outcomes, especially if the client holds the contractor accountable and thus ensures their desired outcome.

Table 1: Findings related to the client's role, perceived benefits, and contractual aspects

	Case 1	Case 2
Changes Client's role	• Client role is in need of change according to interviewees • Lack of resources from client • Need for an active and involved client in early phases	• Client role is changing, and is under development • Lack of resources from client • Need for an active and involved client in early phases
Perceived benefits	• Early inclusion contractor's knowledge – saves time and keeps project to planned schedule • Collaboration between actors expediated decision-making and iterative design process – leading to resource savings	• Early inclusion contractor's knowledge – saves time - anticipating significant time savings at end of project • Collaboration between actors expediated decision-making and iterative design process – leading to resource savings • lack of a clear finish-line impacts utilising economies of scope and scale as well as interconnected material flows
Contractual aspects	• Client had a bilateral contract with the contractor subcontracting the design planning • Disagreement on interpretation of contract between client-contractor • Impact of environmental requirements drives innovation and environmental solutions	• Multiparty contract between client, designer and contractor • Contract perceived as driver for successful collaboration • Contract enabled the actors to focus on technical solutions rather than conflicts

5. Discussion

Client's role

It was found that the role of the client was fundamental for successful project collaboration, as a client active in the project network and daily functions helped facilitate both scheduling and resource use, as successful collaboration was perceived to enable more resource-efficient work streams. Our findings indicate that the client has a larger role to play than previously thought regarding both resource use in the project as well as environmental and sustainability issues. An involved client can streamline the decision-making process, resulting in reduced resource use, both tangible and intangible, while environmental requirements in the contract can drive innovation and new practices, if the client holds the contractor accountable.

The lack of literature on the changing roles of clients might be tied to the amount of interest this field has generated in research. As much research is being focused on the procurement phase, less resources have been allocated to researching project governance and project delivery, where the changing roles are most visible. This might also explain some of the challenges faced in case one, where the roles were in line with traditional infrastructure construction project delivery. If the changing roles and new requirements this places on the actors is excluded from the procurement phase, these matters might get overlooked and thus neglected when planning project execution. As the client's role can differ from project to project, there might be a need for guidelines on how to be an involved public client in collaborative projects.

Perceived benefits

Based on literature, we would expect a decrease in adversity and conflict, in projects utilising collaborative project management methods, as projects where all network actors work together from an early stage of the project are assumed to be more resource effective, both in terms of time and budget [23,33]. These factors could partly be seen in practice. There were perceived benefits related to time savings and resource utilisation in the observed cases, while a low degree of adversity could be identified in case two. The major benefit identified in both cases was tied to the early inclusion of the contractor's knowledge in the design process. In traditional project management models, the late inclusion of contractor knowledge has led to time and resource waste, as plans have needed reworking in the construction phase rather than including possible points of change in the design phase, but with a collaborative project management model, this issue could be corrected and resource waste reduced.

Contract

Complex project networks and large scale infrastructure construction projects are complex to manage [10,22] and research discusses a lack of integration between the organisations participating in the project network, as well as a low productivity level and resource waste [19,23,33,34]. Large-scale infrastructure projects can thus be defined as complex, multidimensional networks, involving several separate disciplines [12,23,35]. These networks are connected by ties, such as contracts. The ties enable resource sharing and collaboration [10], which was especially notable in case two, which was using a contract model including all major stakeholders. In this, focus could be kept on solving technical problems arising during the construction phase, rather than channeling resources into conflict resolution; a point highlighted by all involved actors of the project. This was a stark contrast to case one, where

Applying a network perspective, the actors in the project, the client, lead designer and contractor, apply their resources, for example knowledge and equipment, to engage in project activities, such as design and construction. The actors have their own goals, which impact their engagement in the project as well as project outcome. This could be discerned in the view of the governing contract: in case one, there was a discrepancy in the perception of how the chosen collaborative project model should work. This might be explained by the fact that this was a new project model for the actors, which might have resulted in them falling back on their more traditional roles in design-build projects, while the goals of the parent organisations and the project had been consolidated in the contract in case two. So although the actors were new to the model, they still agreed on the project's goals through the common contract.

An unexpected finding related to the role of the contract with regards to environmental innovation. The client was seen to be able to have a large impact on both environmental impact as well as innovation through the demands stated in the contract. The role of the client in this respect is something that has been touched upon by other literature [13], but their role supporting sustainability in collaborative projects has not been discussed in detail. To ensure outcomes beneficial for the environment, the client needs to communicate with other public institutions, as the requirements often come from local and national governments and regulatory bodies and the matter doesn't solely rest in the hands of the client. This, furthermore, highlights the importance of active client participation in the project, as such matters depend on the client's activity and willingness to both place the demands but also to keep the other actors accountable.

There are, however, limitations to our study, due to method selection as well as case timing. Qualitative methods are beneficial for a deep understanding of a specific context, but rather limited in replicability and generalisability. As the case projects are still ongoing, the data can also only be analysed with the current situation in mind, and can not give a complete picture of a finalised project.

6. Conclusion

Our preliminary results indicate that a collaborative project management model utilised in an infrastructure construction project can promote a more resource efficient approach to infrastructure construction projects, a goal more easily met if the client is an active participant. There are indications that collaborative project management models can lessen the negative impact commonly seen in such projects, as well as create more innovations in the field of the environment, especially if the environmental demands are well written in the contract and the client holds the contractor accountable.

The most important finding is the significance of the client's role in the project. If the client is actively involved in the project, especially in the design phase, they can expedite the decision-making process, resulting in reduced resource use, both tangible and intangible, in the project. As the collaborative project model with two phases is new in the Nordics, there are, however, still some aspects that need further development in relation to the role of the client.

The view of the possible benefits of applying a collaborative project management model is quite unified, with both client, lead designer, and contractor remarking on the expected time and resource savings to be achieved in projects employing such a model. This validates previous findings in literature.

The contractual framework was also important. One of the findings shows that it becomes relevant to discuss the goals, and perception of the collaborative project model amongst the collaborating parties in order to avoid diverging perspectives. When all actors are in agreement and the contract reflects this, collaboration in the construction phase seems to function well, resulting in reduced resource use and thus improving project sustainability. By focusing on the project network for collaboration, the different actors and their goals, resources and activities become more explicit, broadening our understanding of the impact the chosen governance model can have.

For future research, we would propose to either look at more similar projects qualitatively to be able to generalise these results more, or perform quantitative analysis of finished projects that have employed a collaborative project management model, as well as a comparison with projects executed with a traditional management model, to validate, or refute, our initial findings regarding time and resource savings.

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