Procurement and governance choices for collaborative infrastructure projects

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Abstract

Collaborative approaches to infrastructure procurement are increasingly popular around the world due to their potential to provide improved project performance compared to more traditional approaches. The problem is that project outcomes continue to be unpredictable. The authors' previous research shows that this is the case regardless of whether the chosen procurement approach is based on price or non-price selection of the project team. This is a major choice that clients make, but the current research shows that governance choices for project execution are more important. This is significant because clients tend to focus more on procurement choices and typically do not differentiate governance based on those choices. This needs to change as the authors show optimal governance configurations vary on the basis of the chosen type of team selection. For example, three specific governance arrangements for workshops are highlighted for single-teams, while two specific governance arrangements for risk/reward sharing are highlighted for multiple teams. This study identifies these governance actions that are associated with superior time and cost outcomes on collaborative infrastructure projects in Australia run by experienced public sector clients, under the two procurement scenarios. Based on a survey of 320 senior managers, independent sample t-tests were conducted to compare the application of governance actions between three distinct groups of projects, based on type of team selection and type of project outcome. The study provides evidence of the most effective approaches to project governance, in a country that is a world leader. The results provide much needed recommendations for improved project performance, based on large scale quantitative analysis, which before now has not existed. Overall, the study recommends more attention is paid to non-contractual governance under both approaches to team selection, although the specific actions recommended vary.

Author keywords

Collaborative projects; project governance; relational governance; infrastructure, Australia, project outcomes, relational governance, project procurement, Project Alliance, Partnering, Integrated Project Delivery, Early Contractor Involvement

Introduction

The problem addressed by this study is that infrastructure project outcomes continue to be unpredictable, even under the two main approaches to procurement of collaborative infrastructure projects which comprise (1) single-team approach and (2) multiple-team approach. These approaches are differentiated by the degree of price competition evident in tender selection, with the single-team approach involving no price competition (sometimes called 'pure') and a multiple-team approach involving price competition (sometimes called 'competitive) (Lahdenperä 2009; Love et al. 2010). Is it best to select a single team, based on non-price competition, with whom to negotiate project cost, or is it best to have multiple teams engage in price-based competition to determine project cost? This is a major choice that clients make, but this paper shows that governance choices for project execution are even more important.

Governance is defined here as the meta-framework that guides decision making on projects. Regardless of the clients' approach to team selection, governance choices for the on-going management of the project will need to be made. For major projects, these choices are often captured in some form of collaborative procurement model (CPM) under which projects operate. CPMs are used to formalize a relational approach to infrastructure delivery to enhance cooperation between stakeholders on a project. This reduces litigation, which is a major problem in the construction industry. A CPM is therefore defined here as a governance structure that enhances cooperation between the client and service providers for the construction and delivery of major infrastructure assets. There are several key types of CPMs, including Project Alliances, Integrated Project Delivery, Early Contractor Involvement and Partnering. Australia's use and development of CPMs is based on early models developed in the UK, such as Project Alliances and Partnering. Australia's extensive experience with these CPMs and later variants provides an important knowledge base, complementing the experience of other leading regions, including the UK, and the US (Lloyd-walker and Walker 2015). Australia's experience in development of CPMs is reflected in investment of over 16 Billion USD in Project Alliances to between 2004 and 2009 (Wood and Duffield 2009, 7). This vast experience, combined with international demand for advice from Australian experts (Morwood et al. 2008) indicates Australia's leadership in this area.

CPMs aim to generate cooperative social behavior between the client and service providers to manage the high risk of complex infrastructure projects (Love et al. 2010; Walker and Rahamani 2016). This is a relational approach to infrastructure delivery. The management literature suggests that large infrastructure projects have the transaction cost and supplier features that favor such an approach (Gil 2009). These features include asset specificity, uncertainty and strategically important suppliers. The multitude of suppliers on a large infrastructure project creates very complex transactional arrangements between diverse parties that are typically expensive to implement, monitor and reinforce. An infrastructure asset, such as a road, bridge or hospital is also fit for only one use, reducing performance flexibility and increasing the owner's risk. Plus there are below-ground uncertainties and high-level skill requirements driven by technical complexity. These features contribute to the need for effective relationship management over the life of the project. CPMs manage these features through governance structures. This happens through individual governance mechanisms that are, in turn, based on underlying governance actions. This is achieved through the development of sophisticated collaborative governance structures that apply both contractual and non-contractual governance mechanisms (Lahdenperä 2012; Zimina et al. 2012; Abdi and Aulakh 2017). The governance structure comprises the overarching decision-making framework for the project. The structure usually comprises two main types of governance mechanisms – contractual and non-contractual, which can then be disaggregated into their constituent individual governance actions. These relationships have been confirmed by the authors' previous research, as demonstrated in Figure 1 and Table 3.

Clients can chose between a range of governance mechanisms. For example, contractual governance mechanisms include actions to ensure fair risk and reward sharing regimes. Non-contractual mechanisms include actions based on leadership and workshops to build trust and an integrated project team (Abdi and Aulakh 2017). There are many governance actions available to clients, but there is no disaggregated evidence concerning their relative impact on the performance of CPMs. This gap in the literature is based on two sets of literatures: general management and construction management.

Establishing the Gap in the General Management Literature

Existing general management literature acknowledges the need for carefully balanced contractual and non-contractual governance mechanisms for effective inter-business collaboration. From a governance perspective, there are two main bodies of thought. One is concentrated on the evolution of optimal contractual conditions (actions) (eg. Reuer and Devarakonda 2016) and one is concentrated on optimizing the outcomes of cooperation (eg. (eg. Salvato et al. 2017). It is rarer to see studies that seek optimization across contractual and non-contractual choices in the management of collaborative multi-disciplinary alliances, as conducted in the current study. For example, the results of a recent high level broad review article appearing in the Strategic Management Journal is dominated by articles focused on either contractual or non-contractual governance (Reuer et al. 2016), rather than comparing them as is the case here.

Nevertheless, there is group of scholars operating in this nexus (eg. Poppo and Zenger 2002; Krishnan et al. 2016). These scholars are focused on the relationship between the two main types of governance – contractual and non-contractual. They ask: are these two forms of governance complementary? Or are they substitutes? An early study of the German telecommunications industry asked these questions, tied to the types of assets involved in the alliances (Hoetker and Mellewigt 2009). Contracts were found to be best suited to property-based assets and non-contractual governance was found to be best suited to knowledge-based assets. The authors rightly point out that these two main types of governance are not mutually exclusive, so mixed governance of some form is optimal. The current study extends this work, by examining the optimal mix in the construction industry.

A more recent high-level study, in the context of US Fortune 500 firms, found different types of uncertainty provided different types of answers (Abdi and Aulakh 2017). The current study extends this work, by examining optimal arrangements in a particular industry; the construction industry; where environmental uncertainly is often driven by ground and weather conditions, rather than by international political uncertainty, as with the previous study.

The general management studies of collaborative governance focus on different types of alliances than those that dominate in the construction industry. Most of the existing literature in general management focuses on strategic alliances of some form. These alliances are on-going and extend over multiple projects, such as international research and development alliances. In the construction industry, alliances tend to dissolve at the end of a particular project. Nevertheless, the current study draws on key streams from the general literature, particularly transaction cost economics and the resource-based view of the firm.

The enormous body of knowledge on governance appearing in the general management literature informed the derivation of governance actions in the authors' previous work (Chen and Manley 2014). This was based on the streams mentioned above, and more generally on relevant literature that drew on the inter-linked disciplines of strategic management, organization theory, behavioral economics and institutional economics. While the current study provides a novel empirical context, the authors also contribute to conceptual discussion about the relative role of the two main forms of governance, finding that high levels of behavioral

and environmental uncertainty require an emphasis on non-contractual governance to achieve superior project outcomes.

Establishing the Gap in the Construction Management Literature

Turning to the second set of literature underpinning the current work, existing construction management literature focuses on assessing the impact of a single governance mechanism on project performance, in the absence of rigorous comparison or meaningful disaggregation (Ross 2008; Lahdenperä 2012). There are a number of important tangential contributions that relate to the contribution of the current paper.

In the field of alliance studies, the seminal work of Derek Walker and Beverley Lloyd-Walker cannot be overlooked. Working with the authors of the current paper and with the same industry association, these authors have focused on the role of CPMs in building innovation capabilities (Peansupap and Walker 2006; Davis and Walker 2009; Lloyd-walker et al. 2014). Clearly the ability of CPMs to encourage innovation supports improved time and cost outcomes. The contribution of the current paper is to focus specifically on those outcomes.

Other authors examine how the animation of particular innovations can be enhanced within a CPM environment. The cooperation inherent in these delivery systems is useful in enhancing the adoption and benefits of disruptive innovations, such as Building Information Modelling (BIM) and Lean Construction. Indeed a recent action-research study of 12 construction projects in the USA concluded that project cost predictability is improved by using CPMs and lean construction concepts (Zimina et al. 2012). The governance actions covered in the current paper pick up some of these concepts, related to design integration in particular. The value the authors add is in considering a much broader range of governance actions and employing a robust quantitative methodology, allowing for greater generalization.

In a similar vein, an even more recent paper examines the impact of formal and informal relations on BIM-enabled supply chain partnerships (Papadonikoklaki et al. 2017). This mirrors the current study, in many ways, including the finding that strong informal relations are essential to support the ability of a contract to deliver good outcomes. The current study complements this leading contribution, which was based on two Dutch case studies, by providing large scale quantitative evidence in support of the same conclusion. The current study also contributes an essential focus on project time and cost as the dependent variable, and provides much greater disaggregation of potential governance actions under two key procurement scenarios.

No previous studies of note examine the relative importance of a broad range of mechanisms and actions in the construction context. The contribution of this paper is to unpack governance mechanisms into their constituent actions and to compare their effectiveness in terms of time and cost outcomes. The main comparison is between price-based tender selection, which involves multiple teams in the pricing stage of a project, and non-price based tender selection, which involves a single-term negotiating project cost with the client, after having won the right to do so based on competition between profit margins and other non-price criteria, such as reputation, innovation and safety. The governance impact of these scenarios is critical because practitioners need to understand the relative efficacy of detailed courses of action

In response to the above knowledge gaps, this paper reports on the results of a survey which captured the governance perceptions of senior participants of collaborative infrastructure projects in Australia that had experienced public sector clients. Experienced public sector clients run the vast majority of major infrastructure projects in Australia as elsewhere in the world.

The Current Study

The objective of the study is *to explore which governance mechanisms and their underlying actions are most influential on time and cost efficiency under two key procurement options: single-team and multiple-team.* This addresses a major problem for public sector clients who continue to achieve suboptimal project performance despite a slew of investigations into the construction industry's performance and an active community of scholars undertaking related research. CPMs were introduced to overcome performance problems, but they continue to yield unpredictable outcomes. The research question driving this study is: 'What is the best combination of contractual and non-contractual governance for optimal time and cost outcomes on collaborative infrastructure projects under single-team and multiple-team projects?'

The study is of great interest to policy makers and academics as there is currently vigorous debate concerning the best combination of contractual and non-contractual governance mechanisms (Morwood et al. 2008; Department of Main Roads 2009; Department of Infrastructure and Transport 2011; Kelly 2011; Walker et al. 2015; Walker and Lloyd-Walker 2016). We show that this depends on procurement choices. Experts disagree about the benefits of the alternatives presented in this paper. The current absence of statistical evidence fuels ambiguity in the literature (Ross 2008; Department of Treasury and Finance 2009; Kelly 2011).

A large scale survey was assessed as the best method to investigate the research question. A rare opportunity to undertake such a study presented itself in Australia, given the relatively long history of collaborative contracting in that country and the matching development of a very large and active industry association representing the interests of participants. Their contribution resulted in the generation of rare and valuable data set upon which the current study draws. Even with this strong practitioner collaboration, it was not possible to obtain 'hard' data due to the confidentiality clauses and political sensitivity surrounding large infrastructure projects. Nevertheless, the study's strong theoretical framework helps to organize and interpret the perceptual data in a rigorous fashion.

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Theory

The study is based on the previously validated model shown at Figure 1.

[Insert Figure 1]

This model is based on Chen and Manley (2014) which validated two contractual governance mechanisms of relevance here: 1) risk and reward sharing regimes; and 2) service provider responsibilities. Five mechanisms of non-contractual governance were also validated: 1) leadership; 2) team workshops; 3) communication systems; 4) relationship managers; and 5) design integration. The discussion below summarizes the operation of these mechanisms.

Contractual Governance Mechanisms

Risk and reward sharing: In collaborative projects, risk and reward sharing governance actions are usually adopted. These include, for example, comparing the actual outturn costs with the agreed Target Outturn Cost (Love et al. 2011; Hosseinian and Carmichael 2014). Traditionally, it is expected that in collaborative arrangements, the client and service providers will share equal proportions of profit due to cost underrun and the liability for loss due to cost overrun (Morwood et al. 2008). The profit or loss allocated to the key service providers is expected to be split fairly between them, and the overall risk for each service provider is capped at a level equivalent to the loss of their service fee (Morwood et al. 2008).

In recent years, however, it has been argued that collaborative risk mechanisms leave the client to carry the entire project overrun if the project becomes distressed, thus undermining

the concept of risk and opportunity sharing (Department of Treasury and Finance 2009; Department of Infrastructure and Transport 2011).

Service provider responsibilities: It has been suggested that the key service providers should carry the responsibility for rising costs, and be liable for paying a penalty if completion dates are not met (Department of Infrastructure and Transport 2011). The complexity (legal or commercial) associated with achieving a balance between clients versus service providers in terms of responsibilities can result in governance actions that impede positive collaborative behaviors, and may cause additional costs for the client (Kelly 2011).

Non-contractual Governance Mechanisms

Leadership: In collaborative projects, project leaders are selected based on project specific experience and capabilities, cultural alignment to CPMs, and capacity to influence resource availability (Morwood et al. 2008; Love et al. 2015). The literature highlights that the capability to achieve 'best-for-project' decision-making and stakeholder engagement are essential to good leadership (Davis and Walker 2009; Walker and Rahamani 2016). Indeed, a recent study of a large on-going program alliance, used an exploratory case study approach to highlight the value of authentic leadership in enabling collective learning across projects (Love et al. 2015).

Team workshops: Team workshops are important for facilitating organizational alignment (Love et al. 2010; Lahdenperä 2012), joint learning (Love et al. 2015), post-project-review assessment and innovation development (Morwood et al. 2008). In order to be effective, workshops should involve all levels of seniority, a broad range of participant types, and an independent facilitator (Morwood et al. 2008). Due to the time consuming nature of workshops, the degree to which they are applied in infrastructure projects varies (Kelly 2011).

Communication systems: Collaborative projects need a shared information technology (IT) system to facilitate information flow (Azhar et al. 2015) such as BIM (Azhar et al. 2015; Love et al. 2015). Likewise, communication tools, such as an expectation matrix, which is used to align partners' commitments (Love et al. 2010), are also important.

Relationship management: Literature asserts the importance of relationship management for collaborative projects (Davis and Walker 2009; Walker and Lloyd-Walker 2016). Client organizations often introduce relationship managers to collaborative project teams for the purpose of aligning the expectations of and maintaining the relationships amongst all team members (Morwood et al. 2008).

Design integration: The literature indicates that contractors and suppliers should be involved in project design from the early stages to ensure the constructability of the infrastructure (Love et al. 2014).

Although the authors' previous work shows that these mechanisms contribute to performance outcomes, the current study assesses their relative merit to *time and cost* performance specifically and assesses the relative value of 28 previously validated governance actions. In the current paper, our interest is in the impact on time and cost performance as the dependent variable, which was confirmed as a combined variable in our previous research, based on factor analysis.

The mechanism categories in this theoretical framework provide structure for interpretation of results. The mechanism descriptions provide detail concerning the types of contractual and non-contractual governance that potentially impact time and cost outcomes on infrastructure projects. Thus the framework enables a fuller understanding of the research question and its results. In order to answer the research question, a quantitative survey method was chosen.

Methods

A quantitative survey was considered a better approach than qualitative methods, such as case studies, because the research question comprises two sets of rigorous comparisons and demands an assessment of the 'best' outcomes. Such rigor is best accomplished with a quantitative survey method, especially as the authors' previous work has validated key constructs. It was also considered that maximum extension of the knowledge base was achieved through a quantitative survey, as previous research is dominated by qualitative methods.

The sampling procedure is reported in detail in Manley and Chen (2016). Project respondent characteristics are summarized in Table 1. Results are reported for collaborative contracts in general across eight project types, with alliance contracts dominating. Projects procured by inexperienced clients and private clients were excluded from the current study to provide a focus on the most common type of procurement, which is undertaken by experienced public sector clients. Hence, the analysis here captured 244 of the 320 survey responses (76%). This is a sufficient proportion of the sample to ensure the analysis results are reliable and representative.

[Insert Table 1 here]

The measurement scales used in this study were developed and validated using exploratory and confirmatory factor analysis.

Project Governance: The 'Project Governance' scale employed here comprises two contractual mechanisms: 1) risk and reward sharing regimes and 2) service provider responsibilities; and five non-contractual mechanisms: 1) leadership; 2) team workshops; 3) communication systems; 4) relationship managers; and 5) design integration. Each of these mechanisms is underpinned by a series of actions, which represent individual governance features that might be applied in a project. Survey respondents were required to indicate the degree to which they perceived that each action had been implemented in their projects using a 7 point Likert scale framed with: 1 = strongly disagree; 2 = moderately disagree; 3 = disagree slightly; 4 = neutral; 5 = agree slightly; 6 = moderately agree; 7 = strongly agree.

Project Performance (time and cost): Survey respondents were required to indicate the degree to which the pre-agreed performance targets were achieved in their projects using a 7 point Likert scale framed with: 1 = substantially below target; 2 = moderately below target; 3 = slightly below target; 4 = target achieved; 5 = slightly above target; 6 = moderately above target; 7 = substantially above target.

Our previous work examined the role of client characteristics on the performance of collaborative infrastructure projects. That study validated six project groups using cluster analysis, ANOVA tests and independent sample t-tests. The confirmed groups were defined by client sector (public/private), client experience (yes/no), client approach to team selection (single team/multiple teams in the pricing stage) and project outcomes (ranked from very high to very low). The current study draws on four of the six confirmed groups, to provide the focus on experienced public sector clients, excluding clients without direct experience on collaborative projects and excluding private sector clients. Thus the current paper focuses on the most common types of projects. Table 2 shows the project groups forming the basis of the comparisons in the current paper, which assesses the role played by governance in determining the project outcomes. Independent sample t-tests were used to compare the intensity of implementation of each governance action between pairs of project groups and to determine whether the intensity difference between the groups was significant. Those outcomes are tied to the two main approaches to team selection employed by clients, to provide the granulated advice they require in the face of current heated debates in Australia and Europe, regarding the best approach.

[Insert Table 2 here]

Results

For each project group, the mean degree to which respondents perceived that each governance action was implemented in their projects was calculated. This provided an indication of whether each action was applied at a high or low level of intensity by each project group. Results are shown in Table 3. Generally speaking, the table shows that more attention to governance provides better project outcomes. The highest scoring average means, were, perhaps unsurprisingly, recorded by the Very High Group. This suggests that the best performing collaborative infrastructure projects are those that use selected governance actions most intensively.

In comparisons between the groups using t-tests, all significant differences occurred where the governance action was used more intensively by the better performing project group. There were no significant differences where the poorer performing group used a governance action more intensively, reflecting the veracity of the previously validated conceptual model.

Governance actions are applied in two main contexts by clients. At the project procurement stage, clients make a choice about delivery systems that shapes the relative importance of governance mechanisms during the project. This involves the choice between 1) a single-team participating in the pricing stage, where the team is selected based on competition between benchmarked profit margins and non-price criteria and 2) multiple-teams participating in the pricing stage, with the selection of the ultimate team being based on competition between tender prices. T-test comparisons were undertaken within these two scenarios, each of which comprises one well-performing group and one poor-performing group. T-tests were conducted between three pairs of project groups: (1) between the single-team projects: Low v Very High; (2) between the multiple-team projects: Very Low v High; and (3) between the best performing projects: Very High v High. The resultant significant governance actions are shown in Table 4.

Of the four project groups in Table 2, two groups used a single team approach, while two groups used a multiple team approach. Within each pair, very different time and cost performance is evident. How might the use of governance mechanisms explain these differences? These pair-wise comparisons allow us to control for team selection approach and focus on the impact of the governance mechanisms. T-test results indicated significant differences, as shown in Table 4.

Single team selection: Mechanisms associated with high time and cost efficiency

The Low Group and the Very High Group were compared to identify the mechanisms of optimum performance in projects that adopted *single team selection*. As illustrated in Table 4, the tests revealed no significant differences in the implementation of *contractual* governance mechanisms between these two groups; whilst the results indicate significant differences related to the implementation of the *non-contractual* mechanisms 'leadership' and 'team workshops'. In the Very High Group, project leaders appeared to have stronger communication and logistical skills, and engaged with stakeholders more actively; workshops seemed to involve a broader range of participant types, and be used more often for innovation development and team integration. These findings suggest that within collaborative projects that adopted *single team selection*, leadership strategies and more effective workshops could help improve project time and cost efficiency.

Multiple team selection: Mechanisms associated with high time and cost efficiency

The Very Low Group and the High Group were compared to identify the governance mechanisms of optimum performance in projects adopting *multiple team selection*. As shown in Table 4, it was noticeable that the High Group implemented three *contractual* governance actions at a significantly more intense level than the Very Low Group namely: equal share of profit between the client and key service providers due to cost underrun; downside risk capped at a level equivalent to the loss of each key service provider's fee; collective share of project risk through a single agreement of the parties. Regarding *non-contractual* actions, the results in Table 4 revealed that project leaders in the High Group practiced 'best-for-project' based decision making to a larger degree than in the *very low* efficiency projects.

[Insert Tables 3 and 4 around here]

Now, let us allow for heterogeneity in the approach to team selection to explore what differentiated the leading projects.

How did the top group of projects gain their edge?

The t-test results in Table 4 indicate that the Very High Group implemented a number of collaborative mechanisms at significantly more intense levels than the High Group. In the Very High Group, the client and key service providers shared more equally the proportions of loss; service providers shared profit more fairly; and, to a greater degree, each key service provider's overall downside risk was capped at a level equivalent to the loss of its fee. In addition, the project leaders appear to have stronger communication and logistical skills, to make decisions more on a 'best-for-project' basis, and to more actively encourage cooperation between parties, engaging more with community stakeholders. Furthermore, in the Very High Group, workshops involved a broader range of participant types, and were used more to integrate key service providers and facilitate innovation development; the main contractors were also involved to a greater degree.

These results provide a number of perspectives on the most important governance requirements. The first perspective compared the two groups of single-team projects; the second compared the two groups of multiple-team projects; the third perspective described the governance actions that are applied intensively by the two groups of well performing projects; and the final perspective described what separated these two leading groups.

Discussion

The problem addressed by this study is that project outcomes continue to be unpredictable, even under the two main approaches to procurement of collaborative infrastructure projects. Is it best to select a single team, based on non-price competition, with whom to negotiate project cost, or is it best to have multiple teams engage in price-based competition to determine project cost? This is a major choice that clients make, but the current paper shows that on-going governance choices are even more important. We show that the same size does not fit all. Optimal governance configurations change on the basis on the chosen delivery system, with specific non-contractual governance actions determining outcomes under the price-based scenario and specific contractual governance actions being more important under the non-price scenario. It seems that governance for project execution needs to complement governance for project procurement. Hence if procurement governance is heavily contractual (price competition), then execution governance needs to be heavily non-contractual to provide balance, and vice versa.

The results of this study are useful in answering four questions that are important to clients considering infrastructure procurement.

1. If I pursue a single team approach, what are the critical governance requirements?
2. If I pursue a multiple team approach, what are the critical governance requirements?
3. What governance actions drive optimal performance?
4. Does increased governance result in a better performing project?

Although the single-team approach can yield the highest project performance, and a multiple-team approach can yield the lowest performance; neither approach yield cost predictability. The findings here indicate that regardless of approach to team selection, governance mechanisms will determine performance outcomes. This is a momentous finding given that the choice between team approaches is often discussed by practitioners as critical. This is clearly not the case. Instead, the results indicate that governance is more important.

Overall, the results here find some support for earlier findings that non-contractual governance mechanisms are a key driver of performance. Firstly, the five highest scoring governance actions belong to the non-contractual group of governance mechanisms. Secondly, it has been shown that under a single-team approach, the difference between very high time and cost performance, compared to low performance, is predicated entirely on the extent to which non-contractual governance actions are animated.

Yet the evidence is not straight-forward, as the different performance outcomes for projects based on a multi-team approach to pricing owes more to contractual differences than non-contractual differences. These multi-team projects contain greater variation in the use of collaborative contract clauses, than the single-team projects. Thus the finding reflects the fact that multi-team projects comprise a wider range of delivery systems, ranging from alliances through to 'lump-sum with collaboration'. The single-team approach is typically only an option under alliance delivery systems, which appear to contain a closer family of common contract clauses.

Multi-team projects also contained less variation in the use of non-contractual actions, than single-team projects. In this case, non-contractual action was not a key determinant of project outcomes. The literature indicates that competition based on project cost, which marks these projects, is associated with lower levels of trust than a single-team approach where non-price competition is employed to award contracts. It could be that the lower trust engendered by multi-team projects, puts greater emphasis on collaborative contract clauses in determining outcomes. This dynamic fits in with previous research concerning governance and opportunistic behavior (Hoetker and Mellewigt 2009), although there is always the risk that formal contracts will be seen as a sign of distrust, and encourage the opportunistic behavior they are trying to avoid (Poppo and Zenger 2002). Overall, the findings here provide stronger support for the notion that 'formal contracts and relational governance function as complements', rather than substitutes (Poppo and Zenger 2002, 707).

This mixed approach is thought to best manage behavioral and environmental uncertainty (Krishnan et al. 2016), both of which are rife in the construction industry, where inter-disciplinary teams engender intra-team suspicion, for instance, between engineers and architects; and between client and non-client partners. As well as the risk of strategic distortions due to behavioral uncertainty, the construction industry involves earthworks to support built assets, and these 'below-ground' conditions are a key source of environmental uncertainty. The weather is another key source of environmental uncertainty in construction, as it has a big impact for on-site work. So, for this industry, project governance is bound to require mixed actions. More than this, the results here emphasize the value of non-contractual governance in highly uncertain situations.

The mixed approach is also considered to be optimal in managing a context marked by high use of knowledge and property assets (Hoetker and Mellewigt 2009), such as occurs in construction. The value provided here is in unpacking the precise mix of actions that are expected to optimize time and cost performance under the two main methods of procuring projects. On balance, the current study adds weight to conceptual assertions concerning the important role of non-contractual actions during construction projects (Morwood et al. 2008; Love et al. 2010; Walker and Lloyd-Walker 2016). For example, the necessity of non-contractual governance actions in developing team integration and increasing project performance generally has been previously demonstrated (Zimina et al. 2012; Ibrahim et al. 2015; Love et al. 2015; Papadonikoklaki et al. 2017). These earlier studies employ a combination of case studies, action research and expert elicitation to support their findings. The large scale quantitative support provided here yields greater generalizability and canvasses a broader array of possible governance actions.

Conclusions

The current study has provided evidence concerning the disaggregated governance drivers of time and cost performance on collaborative infrastructure projects under two main procurement scenarios, based on a large scale survey. No topic is closer to the hearts of major construction clients, who will appreciate the specific guidance provided here.

Theoretical contribution

Figure 1 shows that seven governance mechanisms underpin the performance of collaborative infrastructure projects. The current study has unpacked the specific governance actions that drive superior time and cost performance under two main procurement scenarios. Under a single-team approach, these differentiating actions, which separate the poorly performing projects from the effective projects, are all non-contractual and fall under the Leadership and Team Workshop mechanisms shown in Figure 1. Under a multiple-team approach, there are two differentiating contractual actions, falling under the Risk and Reward mechanism, and one differentiating non-contractual action, falling under the Leadership mechanism in Figure 1. This does not mean that other actions underlying the mechanisms in Figure 1 are unimportant, it just means that in each scenario, particular attention needs to be paid to the identified actions. These actions are summarized as follows:

Actions that differentiate effective projects under a single-team approach

Leadership

1. Strong communication skills.
2. Strong logistical skills.
3. Decisions on a ‘best-for-project’ basis.
4. Encourage cooperation between parties.
5. Engage with community stakeholders.

Team workshops

1. Workshops involved a broad range of participant types.
2. Workshops were used for innovation development.
3. Workshops were used for integration of key service providers.

Actions that differentiate effective projects under a multiple-team approach

Risk and reward sharing regime

1. The client and key service providers shared equal proportions of profit due to cost underruns.

2. A single agreement was developed to acknowledge that the parties would collectively share project risk.

Leadership

1. Decisions on a 'best-for-project' basis.

The current study finds that the higher the degree to which the identified actions were implemented, the higher the time and cost efficiency of the project. This knowledge refines the model shown at Figure 1, by isolating they *key* drivers of *time and cost* performance

More broadly, the paper contributes to general management debates concerning the appropriate roles of contractual and non-contractual governance, by unpacking optimal mixes in key circumstances. This study in the construction industry context supports earlier findings in the general management literature that (1) contractual and non-contractual governance are complements, not substitutes; and that (2) non-contractual governance becomes more important in contexts with high uncertainty, high asset specificity and/or strategically important suppliers.

Managerial implications

Given the habit of construction participants to focus on contractual obligations, the findings in this paper encourage both clients and construction firms to pay more attention to non-contractual collaborative actions that support overall governance structures rather than just focusing on specific contractual incentives.

The discrete governance actions noted above are for particular attention by construction clients seeking improved project outcomes. The study provides a detailed description of key governance actions based on the client's chosen approach to team selection. Thus the study provides differentiated advice based on the extent to which the client relies on price competition, as opposed to other forms of competition, when choosing the construction team.

The findings are based on Project Alliances and Partnering projects in particular, given their dominance in the study sample. Similar lessons apply for emerging contract types which typically encourage early-contractor-involvement and rely on the same types of governance actions. Indeed, collaborative contracts share common features that provide the findings with a high level of generalizability, given the trend towards improved collaboration on major construction projects across developed countries.

The extensive granulation in the analysis also provides clients with governance actions that lead to best practice performance. The highest level performance was achieved when clients awarded construction contracts based on competition which put more focus on profit margins and non-price criteria, rather than basing contract award on competitive price tenders. This is a hotly debated topic and although the evidence presented here indicates project outcomes can vary a lot either way, clear advice is given here concerning the role governance mechanisms play in determining the fate of projects.

Limitations and future research

In this study, each of the 28 governance actions have been treated as independent. Clearly, there will be interaction effects between the actions and complementary qualitative research is planned to explore underlying dynamics, probably through a case study approach. The effects of factors other than governance on project performance are already extensively covered in the literature, but could be explored in future research. Likewise, the effects of factors other than the clients approach to team selection on the choice of governance structures should be investigated. It would also be beneficial to investigate the reasons for the apparent under-use of the governance mechanisms 'relationship management' and 'communication systems' in the

Australian infrastructure sector. It may also be beneficial to replicate the research approach adopted here to investigate collaborative projects in other regions and/or industry sectors.

Finally, future research is recommended to adapt the approach employed here to contribute more specifically to debates in the general management literature concerning the governance implications of uncertainty (behavioral and environmental) and asset types (knowledge and property), given that the construction industry provides an interesting case study with its complex profile along both dimensions.

Data Availability Statement

Requests for data should be directed to the corresponding author.

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