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Facilitating the Industrial Sector's Adoption of Collaborative Project Delivery Methods

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FACILITATING THE INDUSTRIAL SECTOR'S ADOPTION OF COLLABORATIVE PROJECT DELIVERY METHODS

by

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FACILITATING THE INDUSTRIAL SECTOR'S ADOPTION OF COLLABORATIVE PROJECT DELIVERY METHODS

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In an effort to improve outcomes in the civil and healthcare sectors, clients have adopted collaborative project delivery methods for the delivery of their capital projects. The success stories in these sectors have gathered the attention of clients in the industrial sector, where cost and schedule overruns have become the norm. The central objective of this thesis is to help clients make the transition to this new type of project delivery.

This thesis was written in a three-paper format, where each paper addresses a challenge with the adoption of collaborative delivery methods. The first paper investigates what type of industrial project would be a good candidate for collaborative delivery. Through seven semi-structured interviews and a web-based questionnaire with 49 responses, this paper reveals that risk/uncertainty is the primary driver for using a collaborative delivery method. In contrast to current guidelines, complexity was not found to be an important motivator for using this alternative delivery method. Evidence was also found to suggest that projects with higher dollar value are more suitable for collaborative delivery methods.

The second paper explores lessons learned about the shared risk/reward commercial terms. Seven semi-structured interviews were conducted to explore what practitioners in New Zealand and Australia have learned regarding these commercial terms. The

interviews revealed five important lessons that will help clients in the industrial sector understand and implement these new legal instruments.

The third paper in this thesis develops a framework to compare the performance of a project delivered collaboratively with one that is delivered under a traditional approach. A three-hour long research charrette with 12 industry professionals was used to develop the Project Success Framework. The framework consists of 11 Key Result Areas that clients should use to compare project performance. This framework will help clients determine if collaborative delivery methods are able to produce as successful outcomes in the industrial sector as they have in the civil and healthcare sectors.

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During the course of our lives, we all have defining moments. One of my defining moments was working with Dr. Eric Sheepbouwer. Eric, thank you for introducing me to the subject of project delivery methods; without your influence, I would not have come across this opportunity.

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1. CHAPTER 1 – INTRODUCTION

1.1 The Current State

Like the rest of the construction industry, the industrial sector has been plagued with the underperformance of its capital projects. In 2014, Ernst and Young conducted a study of 365 oil and gas megaprojects and found that 64% of these projects experienced cost overruns, and 73% experienced schedule overruns (Ernst and Young, 2014). In another study, Edward Merrow (2012) found that 65% of the 300 industrial megaprojects investigated failed to meet their business objectives.

The problem of underperformance is not unique to the industrial sector; there are a plethora of articles and investigations that have raised concerns about the success of the entire construction industry. In 2015, KPMG conducted a global survey of construction clients across a wide variety of construction sectors. They found that over 61% of clients had experienced one or more underperforming projects in the past financial year (KPMG, 2015). In a study by McKinsey and Company, they claim "construction has suffered for decades from remarkably poor productivity" (McKinsey & Company, 2017). Another study by McKinsey and Company found that 98% of megaprojects suffer cost overruns of more than 30%, and 77% are at least 40% late (Changali et al., 2015).

In response to the concerning performance of the construction industry, a task force led by Sir John Egan was charged with identifying opportunities that could lead to improved efficiency and quality (Egan, 1998). Egan's landmark report provided the construction industry with several recommendations on how the current situation could be improved. Egan's team placed significant emphasis on the need to integrate the entire construction process, stating, "The efficiency of project delivery is presently

constrained by the largely separated processes through which they are generally planned, designed and constructed" (Egan, 1998). Egan also explains that the sequential nature of the conventional construction process is currently acting as a barrier to incorporating the knowledge of constructors in the design and planning stages of projects. Latham (1994) and Farmer (2016) both reinforce Egan's proposition that the conventional construction process is playing a significant role in the problems with the delivery of capital projects.

1.2 Problems with Traditional Delivery Methods

Egan's criticisms of the conventional project delivery process generated significant interest in understanding why the conventional delivery process results in poor project outcomes. Before these problems are explored, definition of the conventional project delivery process is provided.

The conventional project delivery process is how most clients, suppliers, contractors, and designers engage in business. It is also known as the traditional approach, the design-bid-build (DBB) project delivery method, or the segregated services model (DBIA, 2015; Jackson, 2011). Under the traditional model, the client executes and manages two separate contracts for the design and construction services of their project. The designer and contractor have no legal obligation to communicate, and the client becomes the filter, or mediator, between the two parties. Figure 1-1 shows the contractual structure of the DBB model.

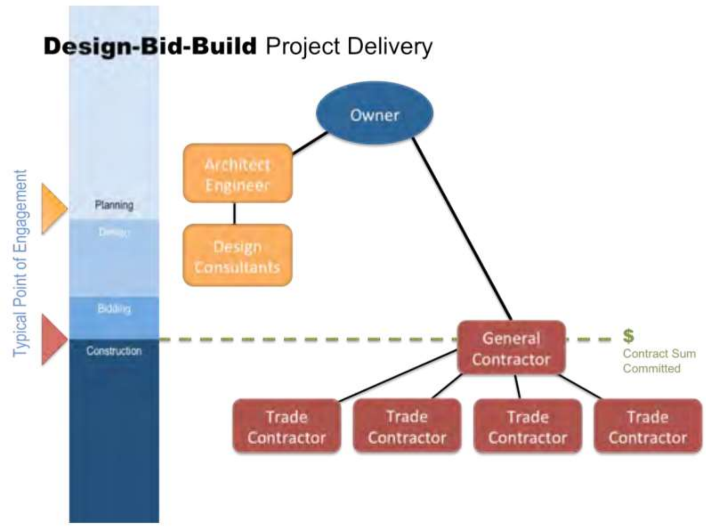

Figure 1-1. Design-bid-build project delivery method contractual structure (DBIA, 2015).

The DBB delivery method is often referred to as a linear delivery method because the different phases of the project execute in a linear fashion; that is, all of the design is completed before any construction begins. Figure 1-1 also shows this sequential nature.

The traditional delivery method has two frequently cited flaws: (1) it creates a misalignment of interests between clients and their service providers, and (2) it creates a fragmented and adversarial working environment (ADIRD, 2015; DTF Victoria, 2006; Hayford, 2018; Ross, 2003). A detailed review of why the traditional delivery process creates these problems is explored in the following sections.

1.2.1 Misalignment of Financial and Non-Financial Interests

With any enterprise, it is in a client's best interest to purchase the best possible service for the lowest price (ADIRD, 2015). Therefore, when a client undertakes any enterprise, they have two primary interests: their non-financial interests, which relate to the product or service meeting their functional needs; and their financial interests, relating to the cost of the product or service. Jackson (2011) explains that when a

client purchases construction services, “incentives are always part of the contract, whether they are explicit or not”, and several authors have identified that the implicit incentives generated by the traditional contracts do not match the two primary interests of the client (Fischer et al., 2017; Hayford, 2018). The section below provides a brief overview of how traditional contracts create a misalignment between the interests of the service providers and their clients.

The two traditional commercial agreements for purchasing construction services are through a lump sum or cost plus agreement. A range of variations to these agreements exist, including unit priced agreements, cost plus with a guaranteed maximum price (GMP), and different fee structures for the cost plus agreements. Although there are a wide range of variations, each one contains similar incentives. The lump sum and cost plus commercial agreements are defined as:

> *Lump Sum:*
>
> Under a lump sum commercial agreement, the contractor is paid a fixed price for the agreed scope of work, irrespective of the actual project costs (Ferreira & Rogerson, 1999).
>
> *Cost Plus:*
>
> Under a cost plus commercial agreement, the contractor is compensated for all of their construction related costs, plus an amount to cover their corporate overheads and profit (Ferreira & Rogerson, 1999).

With a lump sum agreement, it is in the best interest of a service provider to minimize their costs while meeting the minimum conditions of satisfaction of their client (Jackson, 2011). So, while the financial interests are aligned under this model, the non-financial interests of the client and the service provider work in opposing directions. The client must therefore accept the risk that the final product will not meet their functional or quality requirements.

With a cost plus agreement, it is in the best interest of a supplier to maximize their costs as this will increase their absolute profit (Ferreira & Rogerson, 1999). Under this agreement, there is alignment of the project's non-financial interests, as higher quality products will lead to higher project cost and thus profit, but a misalignment of the financial interests because the service provider has no incentive to control project costs. Under this agreement, the client must accept the risk that the project cost will be uncontrolled.

Neither of these commercial terms enable a client to align their service providers' interests with both their financial and non-financial interests. Figure 1-2 provides a graphical representation of this misalignment.

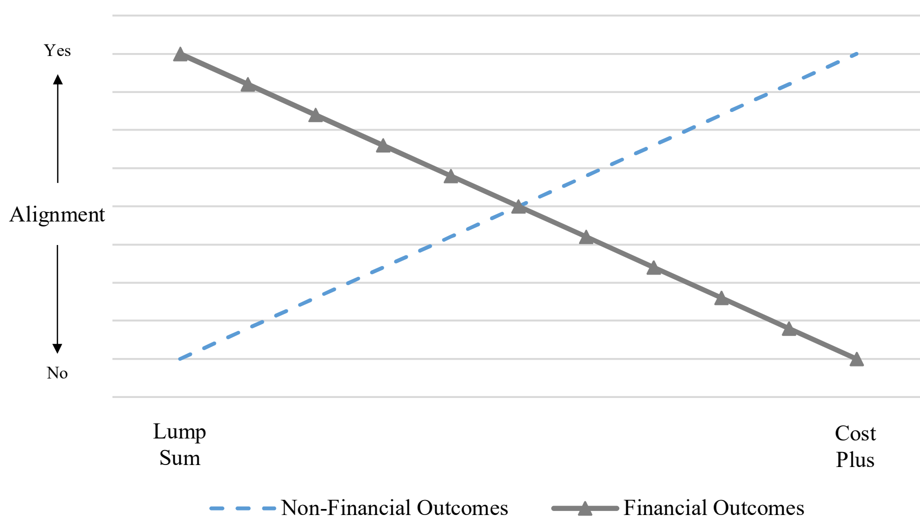

Figure 1-2. Misalignment of interests between clients and their service providers on traditional agreements.

1.2.2 Fragmentation and Adversarial Nature

Another frequent criticism of the traditional contractual models is that they cause a fragmented and adversarial environment. Hayford (2018) explains that under the traditional model, a project effectively becomes the collection of sub projects: where the client has an agreement with the architect/engineer for the design, a separate

agreement with a prime contractor for the construction, and the prime contractor has separate agreements with multiple subcontractors for separate scopes of work. Under this model, each service provider and their respective subcontractors are compensated for their individual scopes of work. The result is that each participant has a strong financial incentive to perform their individual responsibilities well, and little financial incentive to consider how their segment of work influences the overall performance of the project (Thomsen et al., 2016). Evidently, the interests within a single project become fragmented among each of the service providers. The client, however, has no interest in the performance of any one system or piece of equipment. Thomsen et. al (2016) gives a tangible example of how compensating service providers for their individual work, rather than the overall project, can cause the overall project to suffer:

> "Imagine a scenario where the design of the HVAC system is running over budget, but the plumbing design consultant realizes there is a way to revise the plumbing designs that would be cost effective and also allow the HVAC system to be rerouted in a more efficient way. If the plumbing design consultant is running up against its budgeted hours for the design development phase when it realizes this solution, and the HVAC system as currently designed does not hurt the plumbing designer at all, the economic incentive is for the plumbing designer to keep his head down and remain silent" (Thomsen et. al, 2016)

To further the issue, when problems arise, which they inevitably do, it is in each individual's best commercial interest to demonstrate that another party was responsible for the problem and should be liable for its financial repercussions (Hayford, 2018). Under the traditional commercial models, it is better for project participants to find someone else to blame for a problem rather than collectively searching for a solution. In extreme cases, parties are incentivized to search for the mistakes of others so that they can cover up their own shortcomings. Encouraging service providers to point blame rather than problem solve is why the traditional contractual agreements have been titled "inherently adversarial" (Hayford, 2018).

1.3 Collaborative Delivery Methods

In response to the underperformance of large capital projects in the civil sector, government agencies in New Zealand and Australia adopted an alternative form of project delivery known as Project Alliancing (alliancing). The Australian Department of Infrastructure Regional Development define alliancing as “A delivery model where the owner(s), contractor(s), and consultant(s) work collaboratively as an integrated team and their commercial interests are aligned with actual project outcomes” (ADIRD, 2015). Gransberg et al. (2015) point out that alliancing is not to be misconstrued as the Australian term for the U.S. version of partnering.

In 2004, the healthcare sector in the United States adopted a variant of the Australian alliance known as “Integrated Project Delivery” (IPD). The American Institute of Architects defines IPD as “a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction” (AIA, 2007).

In comparison to the separate contracts required to deliver a project under a traditional delivery method, both alliancing and IPD delivery methods consist of a single multi-party agreement between the primary project participants, as shown in Figure 1-3. Delivery methods that contain this multi-party agreement have often been referred to as “collaborative project delivery methods” (Engebø et al., 2020; Lahdenperä, 2012). For the remainder of this thesis, both the alliancing and IPD delivery methods will jointly be referred to as collaborative project delivery methods. Other terms that have

been used to describe these delivery methods include, relational project delivery methods, relational contracts, and alternative delivery methods.

The Australian Department of Infrastructure Regional Development explain that the most significant difference between traditional delivery methods and a collaborative delivery method is the risk distribution (ADIRD, 2015). Traditional delivery methods are founded on the Abrahamson principle that risk should be allocated to the party best able to manage it. In contrast, collaborative delivery methods create a situation where each of the primary project participants collectively share the in the outcomes of the project (ADIRD, 2015).

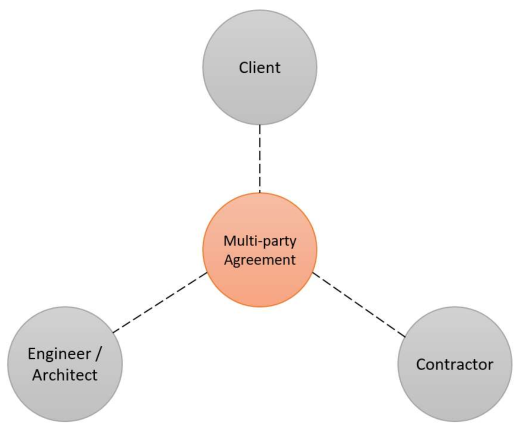

Figure 1-3. Multi-party agreement used on collaborative delivery methods.

Some authors have included project partnering under the umbrella of collaborative project delivery methods (Engebø et al., 2020; Lahdenperä, 2012). Others such as Gransberg et al. (2015) and Beckman-Cross (2016) have discussed that partnering should be separated from these delivery methods primarily because the risk distribution is different between partnering and IPD/alliancing. Under a partnering agreement it is possible for one organization may make profit while other organizations incur a financial loss. Under collaborative agreements, the financial

outcomes of the project are collectively shared by all of the participants. Because this distinction exists, partnering was excluded from this studies definition of a collaborative project delivery method.

1.4 Research Needs

In the civil and healthcare sectors of New Zealand, Australia, and the United States, collaborative delivery methods are now mature systems for delivering capital projects. Research has documented consistent success of these alternative approaches (Cheng, 2012; Cohen, 2010; Gransberg & Jeong, 2019; Ross, 2000), begging the question: why are collaborative project delivery methods not being used in the industrial sector?

This is the question that the Construction Industry Institute (CII) charged two research teams with exploring. CII is a center for research and development of capital projects with an emphasis in the heavy industrial sector. CII commissioned research team RT-271 with exploring the following question: “if the capital project delivery industry did not exist and a new need was created for it, what would it look like?” (CII RT-271, 2012). One of the suggestions RT-271 made was that the ideal delivery system would have collaborative financial management, or more specifically, there would be alignment on compensation. They also identified that the ideal system would contain relational contracts that involve the contractor in an integrated organization (CII RT-271, 2012). These characteristics of the “ideal delivery system” closely resemble those of the collaborative delivery methods used in other construction sectors, which indicates that members of the industrial sector are interested in adopting these collaborative delivery methods.

Following the findings from RT-271, CII charged RT-341 with exploring the business case of using collaborative delivery methods on industrial projects. Of the 85 industrial projects CII's RT-341 studied, they found that those implementing more collaborative and integrated practices had significantly more predictable project outcomes (CII RT-341, 2019). RT-341 concluded that industrial projects using more collaborative practices are benefitting from outcome certainty, and this should be a large driver for adopting collaborative delivery methods.

The findings from both RT-271 and RT-341 demonstrate that there is a strong demand for a more collaborative approach to project delivery in the industrial sector. With RT-341 laying out the business case for adopting collaborative delivery methods, this study was charged with helping clients in the industrial sector make the transition to this new era of capital project delivery. The central research objective of this thesis was:

To help facilitate the industrial sector's adoption of collaborative project delivery methods.

This research was limited to investigating the application of collaborative project delivery methods to industrial projects. The definition of an industrial project was adopted from Barutha (2018) who offers the following definition: "Industrial projects are capital investments designed by engineers to furnish specific process capacities to achieve business objectives, centered on the development of production capability" (Barutha, 2018).

A literature review was conducted to examine where knowledge was lacking on the implementation of collaborative project delivery methods. Three gaps in knowledge were identified that, if addressed, would facilitate the industrial sectors adoption of

collaborative delivery methods. This thesis consists of three related papers that each address one of the needs identified below.

1.4.1 1 – What Project is a Good Candidate for Collaborative Delivery?

Once a client decides to explore alternative project delivery systems, often their first question is: what project is a good candidate for collaborative project delivery? The first paper in this thesis investigates this question. Existing research on collaborative delivery methods suggests that the decision to use a collaborative delivery method may be the single most important decision in a projects lifecycle (DTF Victoria, 2006). Despite the importance of this decision, current guidance on what type of project is suitable for collaborative delivery remains vague, and at times, contradictory.

1.4.2 2 – Lessons Learned About the Shared Risk/Reward Model

The second paper in this thesis explores lessons learned about the commercial terms used on collaborative delivery methods. Collaborative delivery methods employ a shared risk/reward commercial model to promote collaboration between all of the key project stakeholders. These commercial terms are a foreign concept to clients in the industrial sector and a case study conducted by Cohen (2010) revealed that previous clients who have adopted the IPD delivery method took many months of contractual negotiations before they were content with the commercial terms. The objective of the second paper is to help clients understand and implement the terms in the shared risk/reward commercial model.

1.4.3 3 – Framework for Evaluating Success

The long-term adoption of collaborative delivery methods in the industrial sector is contingent on them providing superior outcomes to traditional delivery methods.

Once a client decides to adopt a collaborative project delivery method, it is necessary for them to determine how they will evaluate its performance. It may seem paradoxical that clients could deliver projects without knowing what it means, or how to evaluate their success, but a review of project management literature reveals that the topic of measuring project success has been widely contested (Chan, 2001). The final paper in this thesis addresses this gap by developing a project success framework that will enable clients compare the performance of an industrial projects delivered under different project delivery methods.

1.5 Research Methodology

Each paper in this thesis adopted a unique data collection methodology to best suit the needs of its research objective. The specific methodologies are detailed in each chapter, with data sources including semi-structured interviews, a web-based questionnaire, a research charrette, and a targeted survey.

Chapter 2 used an exploratory mixed methods approach to understand what types of projects are good candidates for collaborative project delivery. Semi-structured interviews were conducted with seven subject matter experts from New Zealand and Australia. This was followed by a web-based questionnaire that was distributed to professionals in the industrial sector. 49 complete responses were received, and this quantitative component was used to test the hypotheses developed from the qualitative interviews.

Chapter 3 used a qualitative approach to explore the lessons learned about the shared risk/reward commercial model. Data collection for this paper was coordinated with the paper in Chapter 2, therefore, the seven semi-structured interviews that were used

to answer the questions of Chapter 2 were also used to answer the questions for Chapter 3.

Chapter 4 used an exploratory mixed methods approach to develop a framework to evaluate the performance of collaborative delivery methods on industrial projects. A research charrette was initially conducted to develop the framework and then a targeted survey was distributed to professionals in the industrial sector to validate the framework. 12 members from the industrial sector participated in a three-hour long research charrette to develop the framework. 41 total responses were received from the targeted survey to help validate the metrics within the framework.

The data collection sources for the three papers are summarized in Figure 1-4.

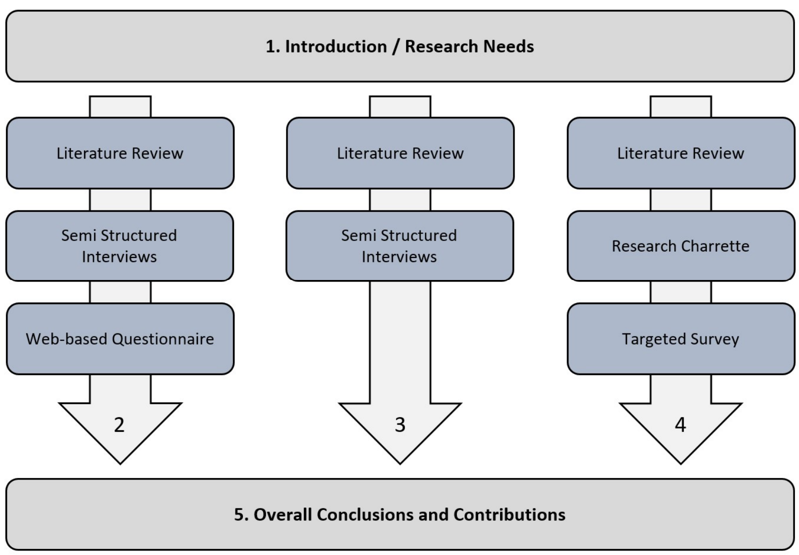

Figure 1-4. Data collection summary of each paper.

Prior to the collection of any data, a standard application was submitted to the Institution Review Board (IRB) of the University of Nebraska-Lincoln. The IRB categorized the research as exempt and was approved with IRB #: 20191219809EX. A full copy of the approval letter is shown in Appendix A.

1.6 Significance of this Study

Many forces are driving industrial projects to change. As our societies continue to grow at unprecedented rates, so does our demand for infrastructure, electricity, and other commodities. A study by McKinsey & Company forecasts that global infrastructure investment will reach $13 trillion by 2030, a 109% increase from the $6 trillion spent in 2013 (Changali et al., 2015). To satisfy the increase in these demands, they also predict that “billion-dollar-plus megaprojects will account for a greater share of these projects”. Edward Merrow’s (2012) also predicts an increase in the average size of projects because doing so allows organizations to benefit from economies of scale.

As the characteristics of industrial projects change, it is important that our methods and management practices adapt to meet the challenges these new projects present. The studies by EY, Merrows, and McKinsey and Company, suggest that the current delivery process is unable to manage the challenges of modern industrial capital projects. The consequences of poor project delivery include losses to company shareholders, insecurity of employment, delay in the provision of key services, and a cost to the world economy.

To deal with the challenges of modern industrial projects, clients in this sector must consider adopting new processes. To help clients overcome barriers that are associated with adopting unfamiliar work processes, the academic community must provide guidance on how and when to use these new delivery methods.

1.7 Organization / Readers Guide

This thesis is organized in a three-paper format. This thesis begins with an introductory chapter, followed by the three related papers, and ends with a concluding chapter. A summary of each chapter is given below.

Chapter 1 informs the reader of the issues associated with the traditional design-bid-build delivery method and establishes the need for this study. The chapter also details the three specific research problems, their methodologies, and the significance of this study.

Chapter 2 presents the first paper. Paper one addresses what type of industrial project is a good candidate for collaborative delivery. Clients will find this paper useful prior to their decision to use a collaborative delivery method.

Chapter 3 presents the second paper. This paper provides a detailed overview of the shared risk/reward commercial model and then explores the lessons from those who have implemented this complex commercial arrangement. Clients will find this paper useful once they have decided to go ahead with a collaborative delivery method and are in the stage of developing their contract.

Chapter 4 presents the third paper. This paper develops a framework to compare the performance of an industrial project delivered under a collaborative delivery method to one delivered under a traditional delivery method. Clients will find this paper important once they have already decided to implement a collaborative delivery method.

Chapter 5 presents the overall conclusions and limitations of this research. It also provides avenues for future research.

2. CHAPTER 2 – WHAT PROJECT IS A GOOD CANDIDATE FOR COLLABORATIVE PROJECT DELIVERY?

2.1 Introduction

It is widely recognized that selecting the appropriate project delivery method for a project is critical to promote good outcomes (DBIA, 2015; Department of Public Works, Queensland, 2008; NSW Department of Commerce, 2005). Some authors have claimed that careful project selection is the single most important decision when using collaborative delivery methods (DTF Victoria, 2006; Young et al., 2016). It is therefore in the interest of clients to understand what types of projects collaborative delivery methods will promote outcomes superior to those achieved through traditional delivery methods. Despite the importance of this decision, the current guidance on what projects suit collaborative delivery methods remains vague and unhelpful. Wood and Duffield (2009) summarize the current literature this way: "There is a plethora of selection guidelines on the use of the alliance delivery method that are inconsistent, confusing, do not reflect current practice, and are not focused on optimizing VfM [value for money]". To help clients in the industrial sector maximize the probability of successful implementation of this delivery method, this research investigates what project characteristics suit collaborative project delivery. This research used a combination of semi-structured interviews and a web-based questionnaire to explore four key project characteristics.

2.2 Literature Review

2.2.1 Alliancing Guidelines

To better understand what types of projects are suitable for collaborative delivery methods, a range of government guidelines, white papers, books, and research articles

on alliancing were reviewed. Table 2-1 presents a summary of the discourse reviewed and presents the project characteristics that each document identified as being important for the consideration of alliancing. The list of characteristics is ordered from the most frequently cited to the least frequently cited.

Table 2-1. Literature Review Summary of Project Characteristics that Suit Collaborative Project Delivery Methods.

Project Characteristic	(ADIRD, 2015)	(DTF Victoria, 2006)	(Ross, 2003)	(NZTA, 2019)	(Young et al., 2016)	(Henneveld, 2006)	(NSW Department of Commerce, 2005)	(Department of Public Works, Queensland, 2008)	(Hayford, 2018)	(Frame et al., 2019)	(Ross, 1999)	**Count**
Tight Timeframe	X	X	X		X	X	X		X	X	X	**9**
High Risk	X	X		X	X		X	X	X		X	**8**
Unclear / Broad Scope		X	X		X	X	X	X	X	X		**8**
Difficult Stakeholder Challenges		X	X		X	X	X	X	X		X	**8**
High Complexity		X	X	X	X		X		X	X		**7**
High Uncertainty				X	X		X	X				**4**
Complex External Threats		X	X				X	X				**4**
Brownfield Project			X			X				X	X	**4**
Need for Innovation				X		X			X			**3**
High Project Value	X			X			X					**3**
Seeking Extraordinary Outcomes							X	X				**2**
High Profile Project							X					**1**

The literature review revealed that the current guidance on what types of projects are suitable for alliancing is not well defined. Risk and complexity are of the most frequently cited characteristics, but each of these terms are complicated topics in their own right and lack clear definition. This makes it challenging for organizations that have not yet implemented this delivery method, because they are left wondering how much risk or how complex is enough to suit this new approach? There also appears to be a relationship between these characteristics but this relationship has not been clearly defined. Another issue with the current guidance is that various characteristics

appear to evaluate the project at different elevations. For example, complex stakeholder issues can be considered a specific risk event. So, how does this relate to the all-inclusive term "risk"? Questions like this have not yet been answered.

2.2.2 IPD Guidelines

Four leading IPD guidelines were reviewed for guidance on when to apply IPD (AIA, 2007; Fischer et al., 2017; Kenig et al., 2010; Thomsen et al., 2016). Despite various authors identifying how important it is to apply collaborative delivery methods to the correct project, these readings offered no guidance on the types of projects IPD is appropriate for.

2.3 Overall Methodology

This study used a sequential exploratory research design to explore the types of projects that are suitable for collaborative project delivery methods. There were two primary data collection phases: Phase A, consisting of semi-structured interviews; and Phase B, consisting of a web-based questionnaire that was distributed to members of construction research institutions. A sequential exploratory design was utilized so that the concepts of risk, complexity, and project size could first be explored and understood prior to the development of the questionnaire. This study aimed to answer the following research question:

What industrial projects are suitable for collaborative project delivery methods?

2.4 Phase A: Qualitative Methodology

Seven interviews were conducted with a mix of clients, consultants, and contractors to better conceptually understand what characteristics indicate a project is well suited for collaborative delivery methods. Participants were selected based on their seniority in

their respective organizations, as well as their experience with alliance projects. The interviews were semi-structured and asked for the participant's thoughts on four characteristics and how they relate to a project's suitability for collaborative delivery. The four characteristics that were explored were: risk, complexity, time frame, and project dollar value. The interview protocol can be found in Appendix B. Interviewees were located in Australia and New Zealand, and the interviews were conducted via Zoom. Each interview lasted between 45-60 minutes. Four of the participants were found through the researcher's professional network; the other three came from referrals provided by the initial four interviewees. Descriptive information on the interview participants is provided in Table 2-2.

Table 2-2. Descriptive Information about the Interview Participants.

Participant	Years' experience	Organization	Position	# of Alliance projects involved with	Location
A	25	Alliancing Consultant	Managing Partner	Executed = 8 Involved = 100+	Australia
B	45	Consultant	Principal	Executed = 1 Involved = 3	New Zealand
C	40	Client	Regional Portfolio Manager	Executed = 2 Involved = 1	New Zealand
D	32	Client	Director of Prequalification's and Contracting	Executed = 1 Involved = 5	Australia
E	35	Client	Director of Infrastructure Procurement	Executed 2 Involved = 20+	Australia
F	26	Contractor	Operations Manager	Executed = 1	New Zealand
G	24	Client	Regional Portfolio Manager	Executed = 2	New Zealand

2.5 Phase A: Qualitative Results and Discussion

2.5.1 Risk

When participants were asked how a project's risk relates to its suitability for collaborative delivery, there was consensus among all seven interviewee's that risk was the single most important variable. In fact, Participant C noted, "risk is the

characteristic that should determine the selection of any PDM". This resounding agreement that risk is the critical factor for selecting a project for collaborative delivery is consistent with the existing literature on alliancing.

Although interviewee's reported risk as the primary driver for using a collaborative delivery method, risk is a term that is often used in a nebulous, catch all, manner. To provide definition to the concept of risk, interviewees were asked to explain their understanding of risk. To help organize the discussion, participants were presented two categories of risk as it is defined by the UK Association for Project Management. The UK Association for Project Management separates risk into "risk events" and "project risk" (Association for Project Management, 2012). Risk events are defined as: "an uncertain event or set of circumstances that, should it occur, will have an effect on achievement of one or more of the project's objectives". Project risk is defined as: "the exposure of stakeholders to the consequences of variations in outcome". Figure 2-1 was developed to help conceptualize the difference between these categories of risk.

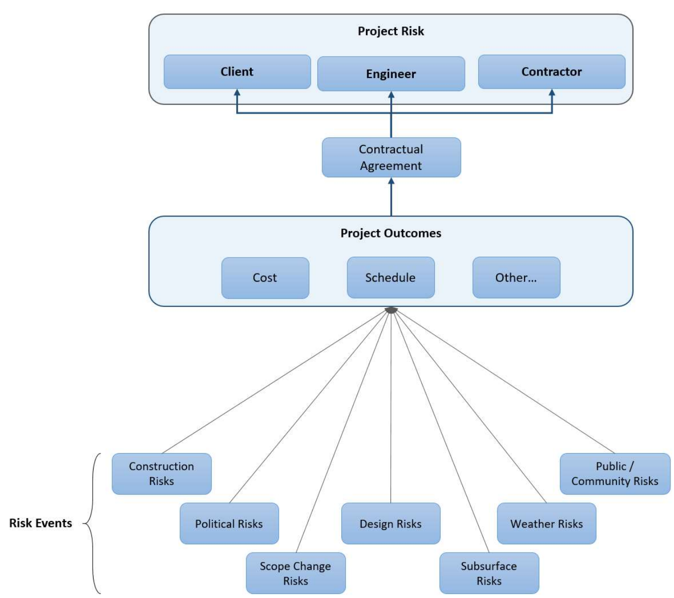

Figure 2-1. A visual representation of risk events and project risk.

The interviewees were presented the two categories of risk and asked if their conceptualization of risk related to risk events or project risk. All the participants indicated that they were referring to risk events. However, the participants reported that "risk" more specifically referred to the aggregate likelihood that a project would fail to meet its defined objectives, rather than a single risk event. This aggregate probability that outcomes would vary from their targets does not appear to have a formal name in risk management literature and among practitioners has assumed the name "risk".

> "The key to selecting the correct contracting strategy is to ask yourself how much don't we know… and that is risk, or more precisely, uncertainty"
>
> **- Participant A**

Participant A suggested that this term "risk" would be more appropriately termed "uncertainty" because changes in outcomes can be both negative and positive. Participant A said, "The key to selecting the correct contracting strategy is to ask yourself how much don't we [the client] know… in my opinion [a projects suitability for collaborative delivery] is a single dimension, and that is risk, or more precisely, uncertainty". Participant G reinforced this concept of uncertainty by explaining that alliancing is suitable for projects "where we haven't quite got everything sorted and we [the client] still need to get the project going".

Each interview participant was asked if there are risk events that create a high uncertainty project. Participant G identified stakeholder management as a critical risk that drove the decision to use an alliance on a $600 million dollar transportation development in New Zealand. The project stretched across 156 different landowners, and accommodating their needs into the execution of the project was of significant concern to the funding agency. Participant G noted that stakeholder management was the primary driver for another alliance project that consisted of installing a new

reticulated wastewater network to 950 private properties. Participant C discussed a $300 million transportation development in New Zealand that was delivered under the alliance model. This project required significant amounts of surcharge loading to consolidate the subgrade to acceptable levels of compaction. The time required to reach consolidation was the primary risk that drove the decision to use the alliance.

Participant A has experience with hospital projects. Participant A said these projects are “ridiculously uncertain because it’s so hard to know what the stakeholders want. They will change their minds up to the last minute, and government will also make changes because there is a natural public interest to do so”. Participant A claimed that the source of uncertainty on hospital projects primarily comes from the difficulty of defining their specifications and design. Participant B, who also has experience with hospital projects, reinforced Participant A’s claims. Participant B said, “The complexity in hospitals is that all of the players want to have a say in the final design. The nurses all need to have a say, surgeons need a say, administrations need a say, the funders need a say, owners of the hospital management need a say because they are responsible for outcomes, and the maintenance team need a say”. Participant B gave an example of a recent $500 million hospital project where there were 23 stakeholder groups that had representatives provide input into the hospital’s conceptual design.

“The complexity in hospitals is that all of the players want to have a say in the final design. The nurses all need to have a say, surgeons need a say, administrations need a say, the funders need a say, owners of the hospital management need a say because they are responsible for outcomes, and the maintenance team need a say.”

- Participant B

The interviews revealed that projects with high uncertainty in their outcomes are good candidates for collaborative delivery. Interesting themes emerged regarding potential sources of this uncertainty. The interviewees had experience in two major

construction industries: civil infrastructure, and hospital projects. For the civil infrastructure projects, the sources of uncertainty appeared to be associated with risk events that could occur after the project's construction had begun. Uncertainty was introduced because risk events could manifest during execution that would impact the projects objectives. A common risk event that was identified was the management of stakeholders that would be impacted by the project, such as private landowners or the general public. It also appeared that the objective of this stakeholder management was to minimize the disruption to the stakeholders affected. In contrast, the primary sources of uncertainty for the hospital projects appeared to stem from the challenge of incorporating multiple conflicting stakeholder interests into the projects specifications and design. This can also be thought of as stakeholder management, but with the objective of maximizing the value of the project to each of the stakeholders. Figure 2-2 provides a graphical representation of the different sources of uncertainty that emerged from the interviews.

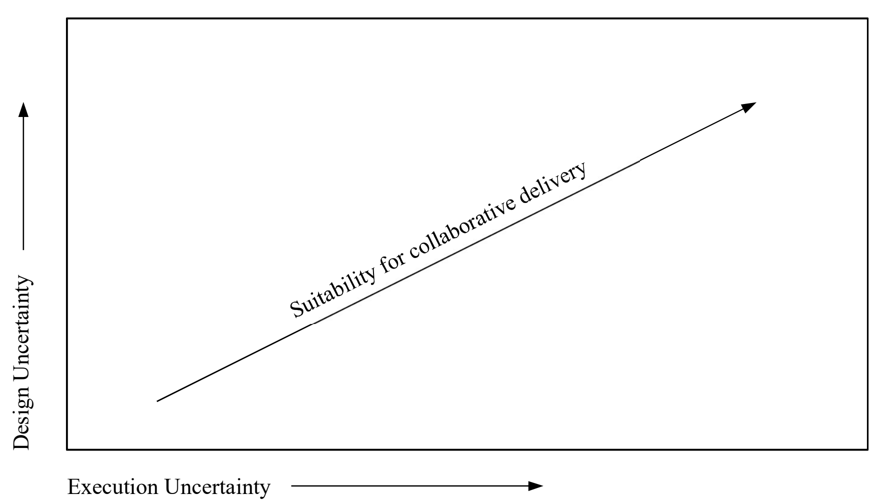

Figure 2-2. Two dimensions of uncertainty that increase a projects suitability for collaborative delivery

2.5.2 Complexity

In contrast to the current recommendations found in literature, each of the interviewees noted that complexity was not a good indicator of a project's suitability for collaborative delivery. Participant C said, "I don't think it is complexity, I think it is risk". Similarly, Participant A said, "it's not complexity, it is uncertainty". It is unclear why literature refers to complexity so frequently regarding the application of collaborative delivery methods. A possible explanation for this is that uncertainty may be more challenging for practitioners to conceptualize than complexity, thus, people default to the term complexity.

> "You can have a very technically complex project with low risk, and you can have simple projects with high risk"
>
> **- Participant C**

The interviewees made it clear that complexity and risk/uncertainty are concepts that can and should be separated. Participant C said: "You can have a very technically complex project with low risk, and you can have simple projects with high risk". Participant C used the previously mentioned transportation alliance as an example. They stated that there was nothing complex about the surcharge loading, but there was very high uncertainty regarding the duration that would be required to reach an acceptable consolidation. Participants D and E also shared that they had delivered simple projects under alliances, and complex projects under traditional agreements.

Although a clear separation between complexity and uncertainty was made, several participants identified that there is a relationship between the two. Participant C mentioned that there are situations where complexity can create uncertainty. They said, "If you have a technically complex problem plus a lack of time, then that

presents a risk and may make a case for sharing that risk”. Participant A also mentioned that there is a relationship between complexity and uncertainty.

This finding supports the previous claim that the primary driver for using a collaborative delivery method is its risk/uncertainty. This also suggests that, in certain instances, a project’s complexity may create high levels of uncertainty, which would make it suitable for this form of delivery; however, simply because the project is technically complex, does not automatically qualify it for collaborative delivery.

2.5.3 Tight Timeframe

The most frequently cited characteristic in literature that makes a project suitable for collaborative delivery is one with a tight timeframe. During the interviews, participants were asked if collaborative delivery methods reduce project delivery time, and if that was a critical factor into their use of the delivery method. In contrast to expectations, the interviewees were not convinced that using collaborative delivery methods reduces overall project duration. Participant C disagreed that collaborative delivery methods reduce delivery time because, in their experience, the procurement time is significantly longer when employing this delivery method. This increase in procurement time was said to counter any savings that result from overlapping the design and construction phases. It is possible that this extended procurement duration is a result of comprehensive procurement policies in Participant C’s organization; however, Participants D and E reported similar doubt over a reduction in project duration from separate client organizations.

> "Time and uncertainty are related in that, if you are in a rush, you haven't had a chance to assess the situation and think it all through"
>
> **- Participant A**

Participant A proposed that the reason why this criterion appears so frequently in literature is because there is a relationship between a project's time constraints and its uncertainty. Participant A said, "Time and uncertainty are related in that, if you are in a rush, you haven't had a chance to assess the situation and think it all through". Participant A explained that the time constraint is less about reducing overall project duration and more about how quickly the project needs to get out to the market. The faster it needs to get to market, the more uncertainty you are likely to have. This could explain why the alliance delivery method has been adopted in New Zealand as an effective way to delivery disaster recovery work. It is very difficult to predict the extent of work required immediately following a natural disaster; therefore, there is a high degree of uncertainty associated with these projects. To summarize, the interviewees indicated that collaborative delivery methods are suitable for projects where there is urgency to begin the work, and that urgency creates high uncertainty regarding the outcomes of the project.

2.5.4 Project Dollar Value

The Australian Department of Infrastructure and Regional Development currently recommend alliancing only for projects that have project dollar value greater than $50 million (AUD) (ADIRD, 2015). The interviewees were asked about their opinions on this minimum project value. Two conflicting opinions were presented.

Four of the participants (A, B, D, and F) disagreed with the minimum project value. Participant D said that they had employed a collaborative contract on projects as low as $20 million (AUD), and thinks that the commercial model can be applied to

projects of any size. Participant A noted that, similarly to the time dimension, there is a relationship between a projects value and its uncertainty. Participant A asserted that project value is a tangible measure, unlike uncertainty, so it may simply be an objective proxy measure for uncertainty.

Three reasons emerged why collaborative delivery methods should be limited to projects with high dollar value. The first reason relates to the cost of forming of a temporary organization. Participant C explained that there are costs with branding, temporary office space, coaches, team building events, vehicle branding, new business systems, etc., so the project needs to be of sufficient value to support these expenses. The second reason raised was that the ongoing project specific overhead costs are higher using this delivery method. In Participant G's experience, these additional project overheads were a result of the additional staff required to run an alliance on a day-to-day basis. Additional staff included full accounting, administrative, and design teams, which are not usually present under traditional delivery models. The third reason identified is that the cost of procuring an alliance is expensive. Participant C explained that the cost to procure an alliance from a supplier's perspective is significantly greater than under traditional models. For this reason, Participant C reasoned that clients should reserve collaborative delivery methods for projects with budgets to support the high procurement costs.

The interviewees were divided on the need for a minimum project value for the use of collaborative delivery methods. An interesting observation was noted between those who were for and those who were against a minimum project value. Those who were in favor of a minimum project value consistently identified the cost of establishing and running a temporary organization as the reason why this delivery method should be reserved for projects with high project value. In contrast, the group who were

against the need for a minimum project value argued that the commercial terms could be implemented on a project of any size.

This observation raises the question: what defines a collaborative delivery method? As mentioned in the introduction, collaborative delivery methods distinguish themselves from traditional delivery methods based on their agreements and commercial terms, but this observation suggests that there could be more to it than that. Yeung et al. (2007) proposed that the alliancing delivery method is defined by both "hard" factors and "soft" factors. The hard factors include a formal multi-party agreement and a shared risk/reward commercial model. The soft factors include common goals and objectives, a win-win philosophy, early selection of contractors, and agreed problem resolution methods, among others. The interviewees indicated that Yeung's "hard" factors can be applied to a project of any size, but the use of the "soft" factors may be dependent on the size of the project. The interviewees specifically noted that the formation of a temporary organization would need to be reserved for projects with sufficient dollar value to support its procurement, formation, and operational costs.

2.6 Phase B: Quantitative Methodology

In a sequential exploratory study the quantitative phase is a follow up to the qualitative phase (Creswell & Plano Clark, 2018). In this study, the quantitative phase served to further explore four research questions. This section provides a review of the research questions, their associated hypotheses, and the development and distribution of the web-based questionnaire that was used to test each hypothesis.

2.6.1 Hypotheses

The four research questions that were investigated through the web-based questionnaire are:

Research Question 1: Is there a relationship between an industrial project's risk and its suitability for collaborative project delivery?

Research Question 2: Is there a relationship between an industrial project's complexity and its suitability for collaborative project delivery?

Research Question 3: Is there a relationship between an industrial project's schedule challenge and its suitability for collaborative project delivery?

Research Question 4: Is there a relationship between an industrial project's dollar value and its suitability for collaborative project delivery methods?

Based on the findings from the semi-structured interviewees, four hypotheses were developed about each of the four research questions. All the interviewees agreed that risk was the primary driver for using a collaborative project delivery method, therefore, the first hypothesis was:

H1: Industrial projects with higher risk are more suitable for collaborative project delivery methods.

In contrast to current guidelines the interviewees provided no indication that a project's complexity is a good indicator of its suitability for collaborative delivery. The second hypothesis was:

H2: There would be no relationship between an industrial project's complexity and its suitability for collaborative project delivery methods.

The interview participants revealed that a project's pressure to begin the work would be a good indicator of its suitability for collaborative project delivery. The third hypothesis was:

H3: Industrial projects with more challenging schedules are more suitable for collaborative project delivery methods.

The interviewees gave indication that projects with higher dollar value were better suited to collaborative project delivery methods, therefore, the fourth hypothesis was:

H4: Industrial projects with higher dollar value are more suitable for collaborative project delivery methods.

Each hypothesis is based on the suitability of an industrial project for collaborative delivery. The Collaboration and Integration Index (C.I. Index) developed by CII's RT-341 was adopted as a proxy measure of a project's suitability for collaborative project delivery. The C.I. Index is a measure of the intensity and frequency of the collaboration and integration principles and methods used on a project (CII RT-341, 2019). The principles are defined as principles that "align the interest and objectives of project stakeholders and to better share the gain/pain", and the methods are defined as those that "help to enhance communication and teamwork among the project team members" (CII RT-341, 2019).

2.6.2 Survey Development and Distribution

Data to test each hypothesis was collected through a web-based questionnaire developed in Qualtrics. Members from CII's research team RT-383 helped with the development and piloting of the questionnaire. This advisory group of practitioners consisted of 9 core members (4 client/owners, 1 contractor, 3 consultants, and 1 supplier), who are hereinafter referred to as the "research team".

Prior to the development of the questionnaire, the research team met to review and update the collaboration and integration principles and methods used to develop the

C.I. Index. The final nine principles asked on the survey are shown in Table 2-3, and the final 21 methods are shown in Table 2-4. Definitions for the list of principles and methods can be found in Appendices C and D.

Table 2-3. The 9 Collaboration and Integration Principles Measured on the Questionnaire.

Collaboration and Integration Principles	
1. Continuous communication and issue resolution	2. Financial transparency among key participants
3. Jointly developed and validated targets	4. Shared risk and reward
5. Access to shared information systems	6. Relational contracting (multi-party agreement)
7. Early involvement of stakeholders	8. Negotiated risk distribution
9. Collaborative and equitable decision making	

Table 2-4. The 21 Collaboration and Integration Methods Measured on the Questionnaire.

Collaboration and Integration Methods	
1. Alternative scheduling method	2. Quality improvement process
3. Co-location	4. Rapid process improvement workshops
5. Constructability planning in the design phase	6. Contract incentives
7. Formal partnering / team building	8. Standardized design techniques
9. Front end planning (FEP)	10. Design to cost (target value design)
11. Joint risk assessment tool	12. Use of technology as an integration tool
13. Multi-party agreement	14. Value engineering
15. Multi-party project management team	16. Value stream mapping
17. Mutual liability waivers	18. Advanced work packaging
19. No dispute charter	20. A3 decision making
21. Preassembly and modular construction	

The equation for calculating the C.I. Index is shown in Equation 1.

$$C.I. Index = \frac{Principles\ Index * Methods\ Index}{100} \tag{1}$$

Where,

$$Principles\ Index = \left[\frac{\#\ Principles\ used}{Total\ \#\ Principles} x\ 100\right] x\ \left[\frac{Average\ intensity\ of\ Principles\ used - 1}{4}\ x\ 100\right]$$

$$Methods\ Index = \left[\frac{\#\ Methods\ used}{Total\ \#\ Methods} x\ 100\right] x\ \left[\frac{Average\ intensity\ of\ Methods\ used - 1}{4}\ x\ 100\right]$$

The questionnaire adopted a similar overall design to that used by CII's research team RT341, in that respondents were asked to identify a project that demonstrated high levels of collaboration and integration (CII RT-341, 2019). The questionnaire first asked for demographic information from the respondent, and the remainder of the questionnaire collected information about the identified project. The collected data was reviewed in Excel for inconsistencies and then input into SPSS for analysis.

Two pilot tests were completed to ensure that the questions were written in a way that would transfer the desired intent to the respondent, and to test for the required time to complete the survey. The initial pilot revealed that the survey required too much time to complete and various questions were rearranged into matrix tables. The reformatting of questions reduced the survey time, meaning that no questions needed to be removed. The research team members also requested additional definition to be provided with each question. This feedback was received through Zoom review sessions.

The questionnaire was distributed to CII member companies, to PTAG's partner companies, to CURT's member companies, and through the professional networks of the research team members. The questionnaire was originally distributed on November 16, 2020, with a planned duration of two weeks, but due to low response rates was left open until January 28, 2021. The analyses performed in this paper includes data collected up to January 28, 2021, but the research team decided to keep the survey open to continue collecting responses past this date. The operationalization of each of the variables used to test the hypotheses is discussed in the following section.

2.6.3 Operational Definitions

Risk / Uncertainty

The interviewee's revealed that uncertainty and risk are terms that are often conflated, and that, while uncertainty is the real construct, the term "risk" tends to resonate better with practitioners. Accordingly, the questionnaire was developed to collect data on the level of risk on the identified project. Risk was defined as: the likelihood that the project will fail to meet its objectives. Respondents were asked to rate the level of risk from very low to very high (1 - 5) for each of the risk categories shown in Table 2-5. A Risk Index was calculated as the average of the 10 risk categories. Examples of specific risk events that could occur within each category was included as an attachment for the respondents, see Appendix E.

Table 2-5. The 10 Risk Categories Measured on the Questionnaire.

Risk Categories	
1. Funding	2. Environmental
3. Geotechnical and Subsurface	4. Scope Change
5. Design	6. Political and Community
7. Weather	8. Land Acquisition
9. Construction	10. Organizational

Complexity

CII's research team RT-305 investigated and developed a tool to measure the complexity of an industrial project. However, their team approached complexity from a management perspective, rather than a characteristic of the project. They state, "the research team chose not to describe complexity primarily in terms of a project's physical features… but rather to describe complexity related to managing projects" (CII RT-305, 2016). The selection of a delivery method should be based on a project's characteristics; therefore, the research team deemed that RT-305's complexity indicators were not suitable for this study. Instead, Wood and Ashton's operational

and technological complexity scale was adopted for this study (Wood & Ashton, 2010). The final items included in the complexity scale are shown in Table 2-6, and each item was asked in comparison to a typical project, ranging from much less to much more complex (1 – 5). A Complexity Index was generated by averaging the 10 items.

Table 2-6. The 10 Complexity Items Measured on the Questionnaire.

Complexity Items	
1. Value of the project	2. Overall complexity of the project's design / engineering systems
3. Number of the stakeholders	4. Complexity of the project's construction methods
5. Need for end user input into the design / engineering options	6. The systems and equipment used on this project were cutting edge
7. Technical knowledge required to complete the design / engineering	8. The systems and equipment on the project were highly interrelated
9. Amount of mechanical and electrical work	10. The review of the project's systems and equipment was complicated and involved many stakeholders

Schedule Challenge

The third hypothesis investigated the relationship between how challenging a project’s schedule is, with how suitable it is for collaborative delivery. Respondents were asked how challenging the projects schedule targets were compared to a typical project, and this was measured on a 7-point Likert scale ranging from much less challenging to much more challenging (1 – 7).

Project Value

Each respondent was asked to provide the dollar value of their identified project. This value was used to test the fourth hypothesis.

2.7 Phase B: Quantitative Results and Discussion

2.7.1 Descriptive Statistics

A total of 49 completed questionnaires were received. Figure 2-3 presents the distribution of responses received from clients, contractors, engineers/designers, and other organizations, and the split of responses that were received from public and private representatives.

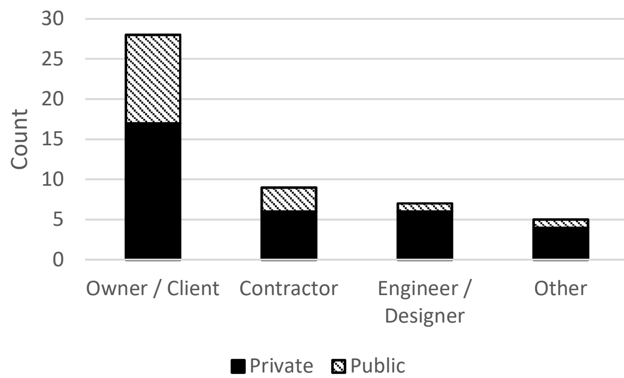

Figure 2-3. Survey response breakdown by organization and type of funding.

The number of projects identified from each industry sector, as defined by CII, and the project's type of funding is shown in Figure 2-4. CII's project sector breakdown is provided in Appendix F. Figure 2-5 shows the distribution of the value and duration of the identified projects.

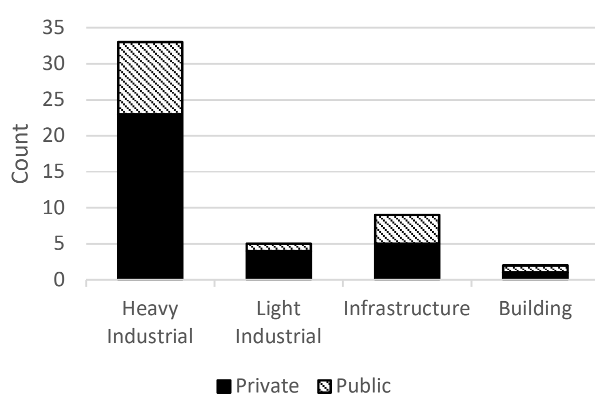

Figure 2-4. Survey response project breakdown by sector and type of funding.

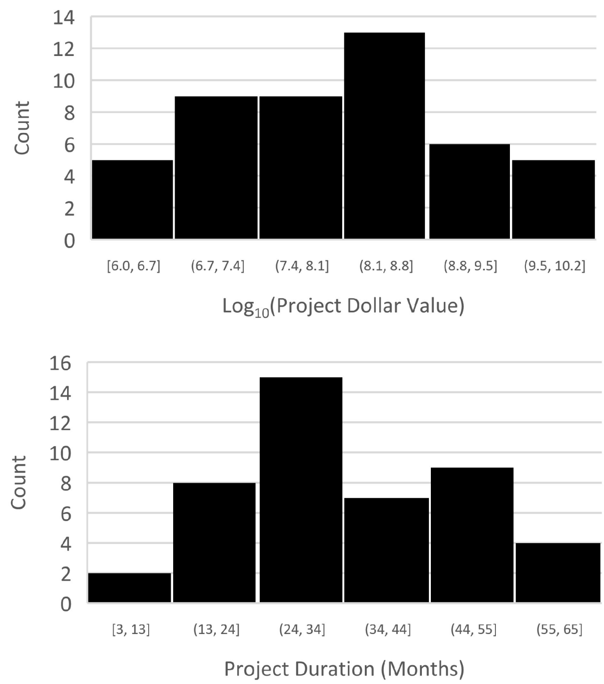

Figure 2-5. Distribution of the value and duration of the identified projects.

2.7.2 Risk / Uncertainty

For each of the 49 identified projects, a Risk Index was calculated based on the 10 items defined in Section 2.6.3 (Mean = 2.845, Std = 0.612). Cronbach's alpha was used to evaluate the internal consistency of this index, which was .821, exceeding the standard of .70 suggested by Nunnally (1978) for exploratory research. Figure 2-6 shows a graph of the Risk Index (x-axis) plotted against the C.I. Index (y-axis).

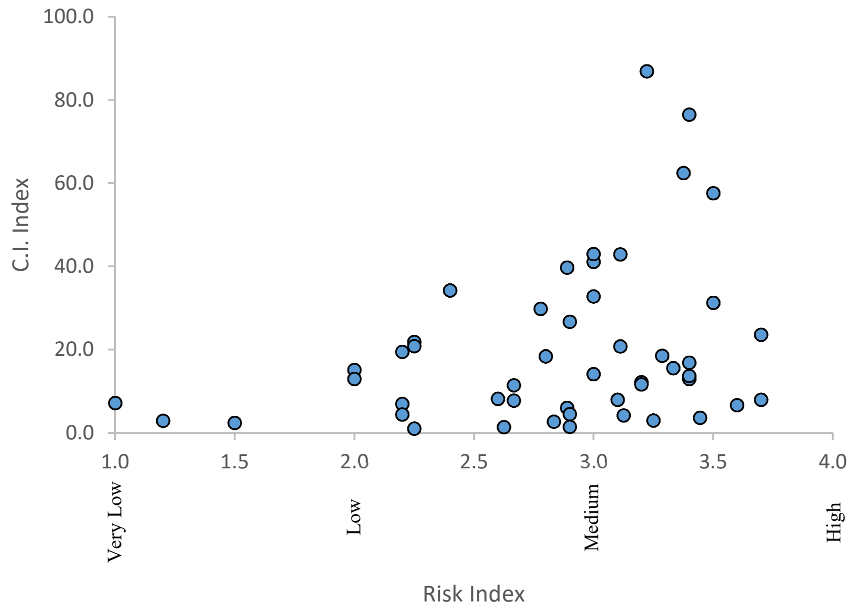

Figure 2-6. Relationship between the Risk Index and C.I. Index.

Visually, there appears to be a relationship between the level of risk of an industrial project, and the amount of C.I. methods and principles being used. Pearson's correlation test was conducted to test this relationship. Table 2-7 shows that there was a significant linear relationship between a projects risk and its C.I. Index, $r(47) = .318$, $p = .026$, providing support for the first hypothesis.

Table 2-7. Pearson Correlation of Risk and C.I. Index.

Variable	Mean	Std	N	Correlation	P-value
Risk Index	2.845	.612	49	0.318	**0.026**
C.I Index	19.880	19.574	49		

Figure 2-7 shows that industrial projects with medium-high risk (>3) appear to have higher variation in the number of C.I. methods they are willing to employ. The variability in the number of C.I methods and principles used can be represented by the standard deviation. The standard deviation in the C.I. Index for projects that had risk index greater than 3.0 was 23.4, and the standard deviation for those projects with risk index less than 3.0 is 11.2. Figure 2-7 captures this difference in variation. The

difference in this statistic shows that projects with high risk are using a much wider range of C.I. methods and principles than those with low risk.

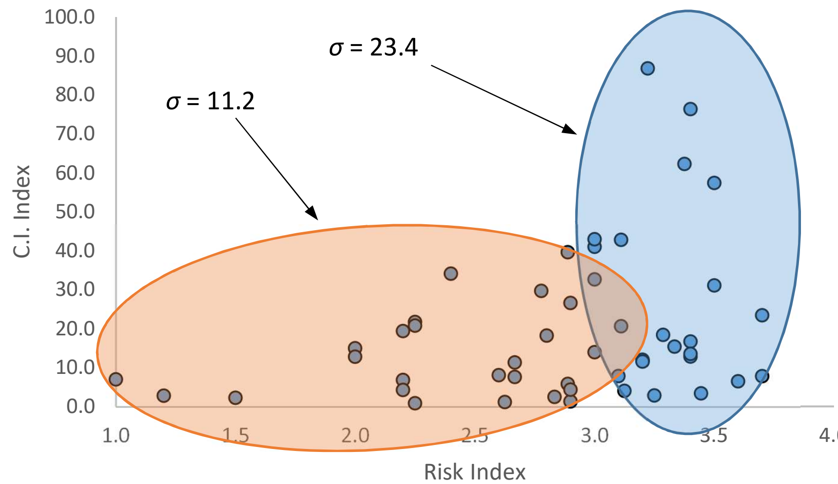

Figure 2-7. Comparing the standard deviation of projects with low risk to those with high risk.

While a significant relationship was found, the degree of association between the variables is low to moderate. Figure 2-8 shows that there is a group of projects with high risk but low C.I. Index. A plausible explanation for why these projects did not employ more collaborative practices is that their organizations were not experienced with the implementation those practices. Additionally, using CI methods and principles can be viewed as its own risk to an organization that is not experienced with their implementation. Organizations may therefore choose to avoid adopting new practices on projects that are already high in risk as a means to protect themselves from the inherent risk of the project. Doing things, “the way they have always been done”, acts as a risk mitigation strategy because the organization is familiar with the process, even if that process is not optimal.

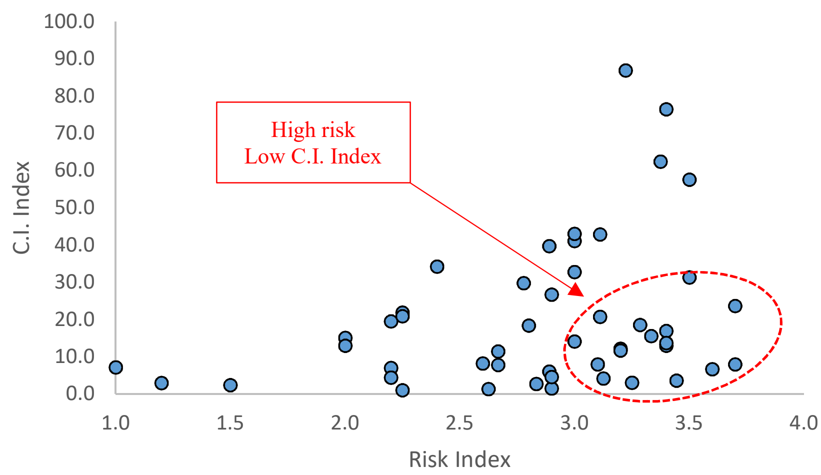

Figure 2-8. Identifying projects with high risk and low C.I. Index

2.7.3 Complexity

For each of the 49 identified projects, a Complexity Index was calculated based on the 10 items defined in Section 2.6.3 (Mean = 3.582, Std = 0.566). Cronbach's alpha was used to evaluate the internal consistency of this index, which was .815, exceeding the standard of .70 set forth by Nunnally (1978). The Complexity Index and the C.I. Index were plotted in Figure 2-9, and visually indicate that there is no relationship between an industrial project's complexity and its C.I. Index.

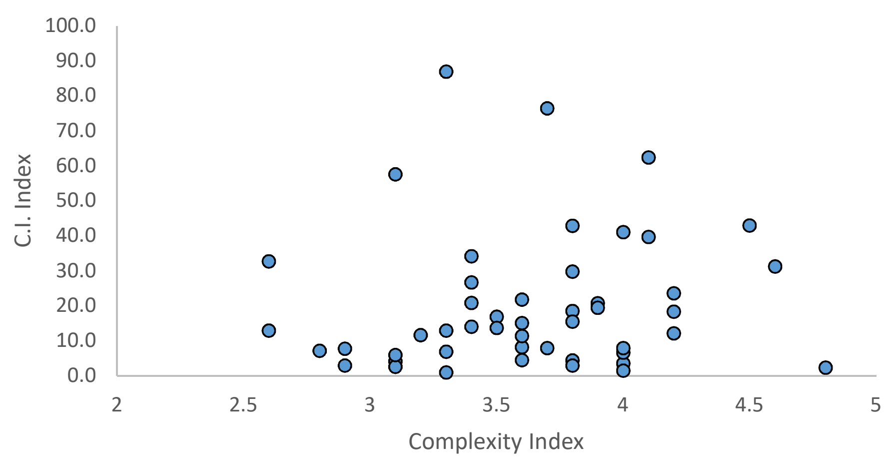

Figure 2-9. Relationship between the Complexity Index and the C.I. Index.

To test the second hypothesis a Pearson's correlation was conducted between the Complexity Index and the C.I. Index. Table 2-8 presents the results of this correlation test. This statistical test reveals that there is not sufficient evidence to conclude that there is a significant relationship between a projects complexity and its C.I. Index, r(47) = .162, p = .265, which supports the second hypothesis.

Table 2-8. Pearson Correlation between Complexity Index and C.I. Index.

Variable	Mean	Std	N	Correlation	P-value
Complexity Index	3.582	0.566	49	0.162	**.265**
C.I Index	19.880	19.574	49		

2.7.4 Schedule Challenge

The third hypothesis investigated if there is a relationship between how challenging an industrial project's schedule is and the number of C.I. methods and principles used. Figure 2-10 plots the level of challenge of the projects schedule compared with a typical project (x-axis) against the C.I. Index (y-axis).

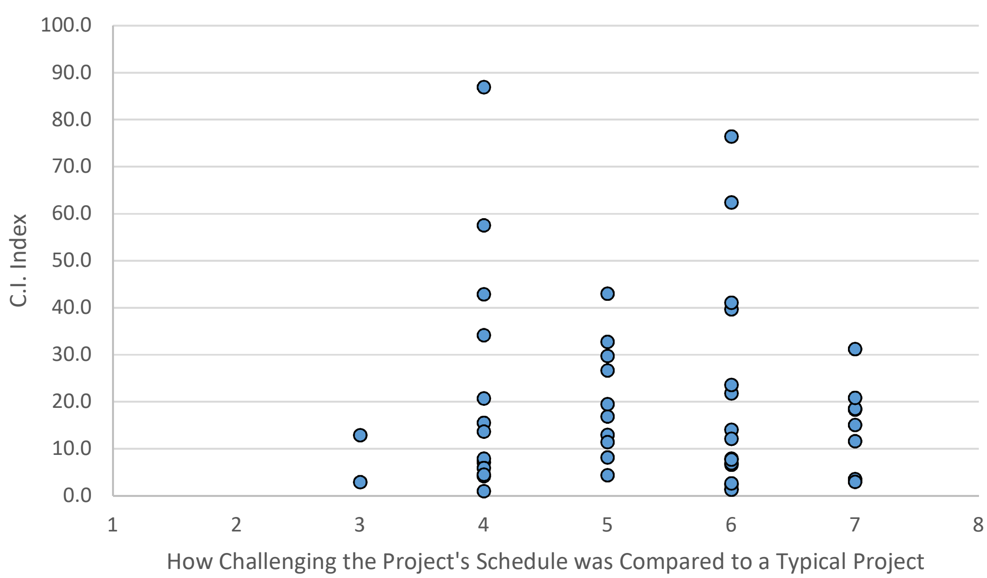

Figure 2-10. Relationship between the projects schedule challenge and the C.I. Index.

Due to the ordinal nature of the schedule compression variable, a Spearman's correlation was conducted to test the rank order relationship between the two variables. Table 2-9 presents the results of this analysis. The Spearman's correlation reveals that there is not sufficient evidence to conclude that there is a significant relationship between how challenging the projects schedule was and its C.I Index, rs(47) = -0.010, p = .945.

Table 2-9. Spearman Correlation between Schedule Challenge and C.I. Index.

Variable	Mean	Std	N	Correlation	P-value
Schedule Challenge	5.306	1.158	49	-0.010	**0.945**
C.I Index	19.880	19.574	49		

2.7.5 Project Dollar Value

The fourth hypothesis investigated if there is a relationship between a project's dollar value and the number of C.I methods and principles used. The value of the projects identified by respondents were highly positively skewed (3.056), therefore the project value variable was log transformed to meet the normality assumptions that are necessary when testing for bivariate association (Kowalski, 1972). Figure 2-11 shows a plot of the log transformed project value (x-axis) with the C.I. Index (y-axis).

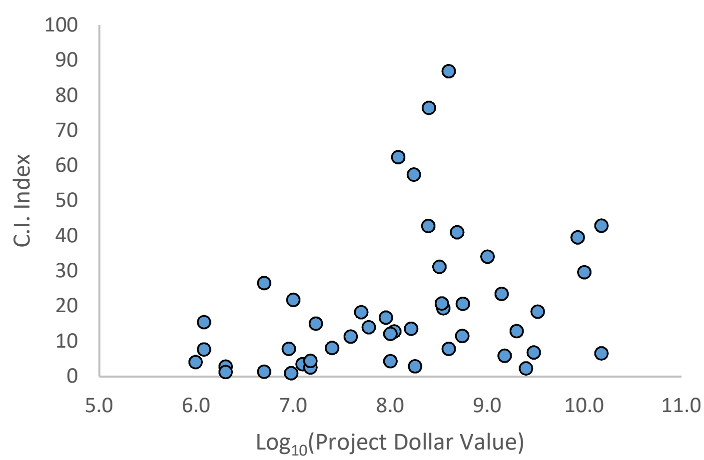

Figure 2-11. Relationship between the dollar value of the project and the C.I. Index.

Pearson's correlation test was conducted to test the fourth hypothesis. Table 2-10 shows that there was a significant linear relationship between the log of the project value and its C.I. Index, r(45) = .325, p = .026. This relationship can be interpreted as follows: as the value of an industrial project increases in order of magnitude, there is a linear increase in the number of C.I. methods and principles used.

Table 2-10. Pearson Correlation between Project Value and C.I. Index.

Variable	Mean	Std	N	Correlation	P-value
Log(Project Value)	8.087	1.132	47	0.325	**0.026**
C.I Index	19.880	19.574	49		

2.8 Overall Discussion

The purpose of this study was to understand what type of industrial projects would be good candidates for collaborative delivery methods. This study used semi-structured interviews with Project Alliance expects from Australia and New Zealand followed by a survey of members from the industrial sector to explore how four project characteristics influence a projects suitability for collaborative delivery.

The main contribution of this study is that it identifies that a project's risk, or more precisely, the uncertainty of its outcomes, is the primary driver for using a collaborative project delivery method. This finding was found unanimously throughout the series of interviews and then supported quantitatively through a web-based questionnaire. This finding brings clarity to the existing literature on the types of projects that collaborative delivery methods are suitable for. This knowledge will help support future research on the application of collaborative delivery methods, which will help clients from all construction sectors develop their procurement policies.

Because this delivery method is suitable for projects that contain high levels of risk/uncertainty, clients may be hesitant to implement a new practice to these types of projects. Implementing an unfamiliar delivery method to projects with high levels of risk/uncertainty may be viewed as taking a “leap of faith”. The web-based questionnaire revealed that there are still many industrial projects that contain high levels of risk/uncertainty but do not employ many collaborative practices. This may stem from the belief that implementing new practices introduces its own risk; therefore, many organizations default to what they are used to, and what they are comfortable with. The reality is that continuing with existing practices contains the risk of producing the same substandard project outcomes that the industry is currently producing. Collaborative delivery methods provide clients with an opportunity to change this, but one of the barriers that has yet to be discussed it that these delivery methods are suitable for projects that clients are simply not willing to experiment on.

Complexity is frequently discussed in alliancing guidelines as a good indicator for collaborative delivery. In contrast to the recommendations from literature, the interviewees suggested that complexity was not a good indicator for collaborative delivery. The quantitative findings provided support for the claims made by the interview participants in that no relationship was found between an industrial project’s complexity and the amount of collaboration and integration methods and principles that were used.

The most frequently cited characteristic for using a collaborative delivery method is a project with tight time constraints, but little definition has been provided on this characteristic. The interview participants suggested that collaborative delivery methods are good candidates for projects that need to begin work as soon as possible. The interviewee’s related this characteristic to uncertainty, as projects that need to go

to market sooner will have less time for planning and thus more uncertainty. The quantitative phase of this study was unable to find a relationship between how challenging an industrial project's schedule was, and how many collaborative practices they employed.

Although the quantitative results of this study were not able to support the findings from the qualitative phase, this variable should not be discarded from future research. The frequency in which this variable appears in literature suggests that it is an important characteristic and should not be neglected. It is possible the subjective operationalization of this variable introduced error into the quantitative analysis, potentially confounding the results.

A minimum project value for collaborative delivery appears to be common policy among government agencies in New Zealand and Australia. The Australian Department of Infrastructure and Regional Development guidelines recommend that alliancing be reserved for projects larger than $ 50 million (AUD) (ADIRD, 2015). The interview participants were divided on whether a minimum project value was necessary to deliver a project under a collaborative delivery method. Part of the disagreement appeared to stem from the participants having different opinions on what constitutes a collaborative delivery method. Further research is required on whether collaborative delivery methods require a minimum project value.

To date, there have been no studies that have compared the distribution of costs between a collaboratively delivered project and a project delivered under traditional models. Such a study could identify how and where the costs differ between the two delivery methods and this could help to answer questions relating to a minimum project value necessary to support collaborative delivery.

2.9 Conclusions

Prior to this effort, little work has been conducted on understanding what type of project is suitable for collaborative project delivery. The major contribution of this study is uncovering that a projects risk, or more precisely, a project with high uncertainty of its outcomes, is the fundamental driver for using a collaborative delivery method. Additionally, in contrast with current guidance, this study found no evidence to support that a project's technical complexity is a good indicator of its suitability for collaborative project delivery. These findings will help clients in the industrial sector with identifying projects that will have the greatest probability of benefitting from this new type of project delivery.

3. CHAPTER 3 – LESSONS LEARNED ABOUT THE SHARED RISK / REWARD COMMERCIAL MODEL

3.1 Introduction

One important feature that separates a collaborative delivery method from other traditional delivery methods are its commercial terms (ADIRD, 2015; DTF Victoria, 2006). These commercial terms, often referred to as the "shared risk/reward" agreement, are a fundamentally new way for clients to engage with their engineering and construction service providers. The shared risk/reward model separates profit and overheads from direct project costs, and shifts the basis of profit from an individual's performance to the overall project's performance, providing stakeholders with a monetary incentive to collaborate (AIA, 2009)

The shared risk/reward agreement is considerably more complex than traditional agreements, and since its appearance in the late 90's, little research has been completed to understand the effectiveness and practical implications of each component in this agreement. The Construction Management Association of America (CMAA) developed an owner's guide to project delivery methods. In this guide they state that one of the disadvantages of IPD is "agreement on the criteria and the final IPD contract can be very difficult and can take an inordinate amount of time and effort, for which the owner may be paying, if not in money then in time" (CMAA, 2012).

The objective of this paper is to help reduce the time needed for clients in the industrial sector to familiarize themselves with these new commercial terms. This is achieved by first providing a detailed review of the commercial model, and then semi-structured interviews with practitioners are used to provide lessons learned on the use

of the shared risk/reward commercial model. The lessons captured will help clients in the industrial sector understand these complex commercial terms and will help them develop their own shared risk/reward models for collaboratively delivered projects.

3.2 Overview of the Shared Risk/Reward Model

This paper first provides a detailed overview of the shared risk/reward commercial model to familiarize the reader with the structure of the commercial terms. The shared risk/reward model is employed on both IPD and alliancing project delivery methods and presents an elegant way to prevent the issues of misalignment and fragmentation caused by traditional commercial models. Two extracts from IPD and alliancing guidelines presented in Table 3-1 demonstrate that, conceptually, the two commercial models strive to achieve the same objective; that is, to remunerate non-owner participants (NOPs) for their direct costs, and to tie their profit to the client's evaluation of project success.

Table 3-1. Comparing Extracts from Alliancing and IPD Commercial Models.

IPD Commercial Model (Fischer et al., 2017)	**Alliancing Commercial Model** (ADIRD, 2015)
"All or part of the participants' profit is placed at risk and profit may be augmented if project performance is met or exceeded. Individual profit is not a function of the amount of work performed, or of individual productivity, but is proportionate to overall project success."	*"Under the Risk or Reward Regime, the NOPs agree to put all (or a certain percentage) of their Corporate Overhead and Profit at risk, tied to their performance against the TOC [target outturn cost] and other non-price project objectives."*

The objective of the shared risk/reward model is to create a situation where all parties share in the benefit of a successful project, and equally, share in the pain from a

poorly delivered project. The intent of the shared risk/reward model is shown in Figure 3-1.

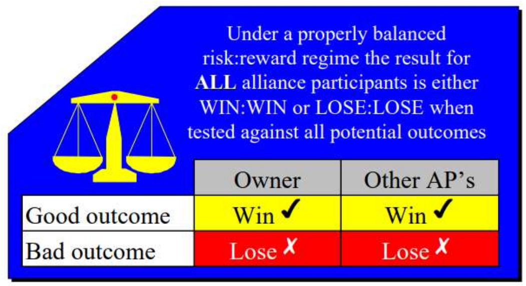

Figure 3-1. Objective of the shared risk/reward commercial model (Ross, 1999).

This win:win, lose:lose proposition is achieved by tying the profit of the NOPs to the performance of the project (Fischer et al., 2017). In turn, this creates a "best for project" mind set, rather than the "best for myself" mind set found in traditional models (Kenig et al., 2010). Tying the profit of NOPs to the performance of the project, rather than their individual scopes of work, actually provides NOPs with a monetary incentive to collaborate (AIA, 2009), whereas in traditional models, collaboration is expected simply out of goodwill. Additionally, expanding the definition of performance from just cost metrics gives clients an opportunity to incentivize their non-financial project outcomes, avoiding the misalignment of interests described in the introduction.

Although the alliancing and IPD extracts show that both the commercial models strive to align the compensation of the service providers with the performance of the project, there is a notable difference in the amount of literature that exists on how each delivery method achieves that goal. Literature on IPD and how profit should be tied to performance is light; in fact, most sources do not provide practical guidance on how to implement this principle. Conversely, alliancing guidelines have created a clear and consistent structure on how to do this. This is possibly because IPD has been adopted

by private clients in the healthcare industry, whereas alliancing has primarily been used by public agencies and as such, has had formal procurement guidelines developed.

Considering that both IPD and alliancing seek to achieve the same objective, and also considering that the existing literature on the alliance commercial model is more comprehensive, this paper adopts the terminology and structure of the alliance commercial model.

The shared risk/reward commercial model utilized on alliance contracts is often characterised as a "3-limb model" (ADIRD, 2015; DTF Victoria, 2006; Gransberg et al., 2015; Ross, 2001). Under the 3-limb model, each NOP that is a signatory to the agreement will be compensated as follows:

> **Limb 1**: Reimbursed for the actual direct cost of the work (including rework and wasted effort) and project-specific overheads.
>
> **Limb 2**: A fee to cover profit and non-project-specific (corporate) overheads.
>
> **Limb 3**: An increase or reduction in compensation dependent on the overall performance of the project.

A graphic representation of the 3-limb commercial model is displayed in Figure 3-2.

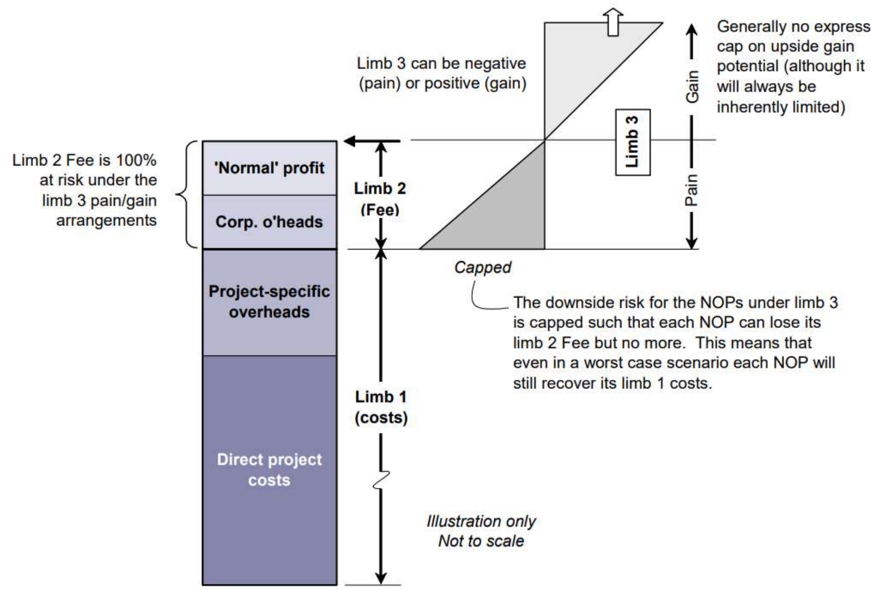

Figure 3-2. The 3-limb commercial model (DTF Victoria, 2006).

3.2.1 Limb 1 and Limb 2

What separates the shared risk / reward model from other commercial models is the Limb 3 component. The Limb 3 component enables clients to adjust their NOPs profit based on the performance of the project. For this reason, this study focuses on capturing lessons learned specifically relating to the Limb 3 incentive mechanism. For principles and recommendations on the development of the Limb 1 and Limb 2 components, readers should refer to (DTF Victoria, 2006) and (ADIRD, 2015).

3.2.2 Limb 3

The Limb 3 mechanism is the key mechanism that incentivizes exceptional performance in cost and non-cost areas (ADIRD, 2015). The Limb 3 component incentivizes NOPs to achieve exceptional performance in Key Result Areas (KRAs) by adjusting their profit through two mechanisms: the cost performance mechanism, and the non-cost performance mechanism.

Cost Performance Mechanism

The cost performance mechanism incentivizes NOPs to achieve the client's cost targets by sharing in any cost underruns and cost overruns (ADIRD, 2015; DTF Victoria, 2006; Ross, 2003). This is often referred to as "pain/gain sharing", and the client and the NOPs typically share pain/gain at a 50:50 split. The potential downside, "pain", for the NOPs is usually capped at their total limb 2 fee, after which the client will absorb any further cost overruns. A graphic representation of how the cost performance mechanism functions is presented in Figure 3-3.

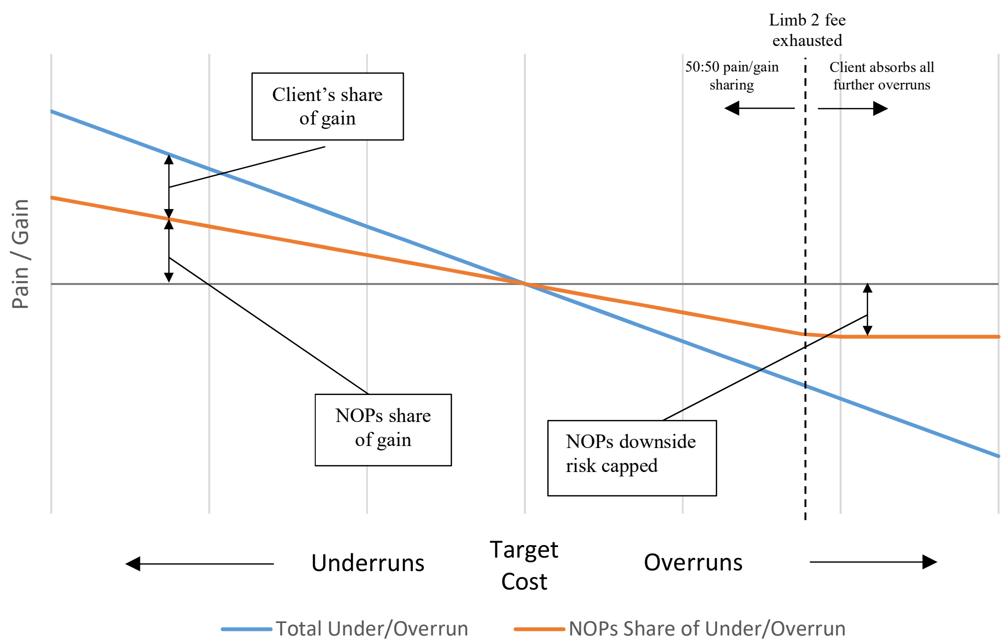

Figure 3-3. Typical cost performance mechanism.

Non-Cost Performance Mechanism

The non-cost performance mechanism enables clients to incentivize their NOPs to achieve their non-financial objectives. The non-financial objectives are incentivized by the Overall Performance Score (OPS). The OPS is a weighted score of the NOPs performance in various non-cost KRAs. The non-cost KRA scores are also calculated as a weighted score of their respective Key Performance Indicator (KPI) scores. The KPI scores, KRA scores, and OPS each range between -100 to 100. A graphic

representation of the relationship between the three scores is shown in Figure 3-4. The KPI scores are calculated based on an agreed relationship between a specific KPI and its KPI score. Figure 3-4 shows that this relationship does not need to be linear and will need to be negotiated between the client and their NOPs. The agreed relationship between a KPI and its KPI score should be designed so that a score of 100 should indicate exceptional performance, and a score of -100 should represent substandard performance.

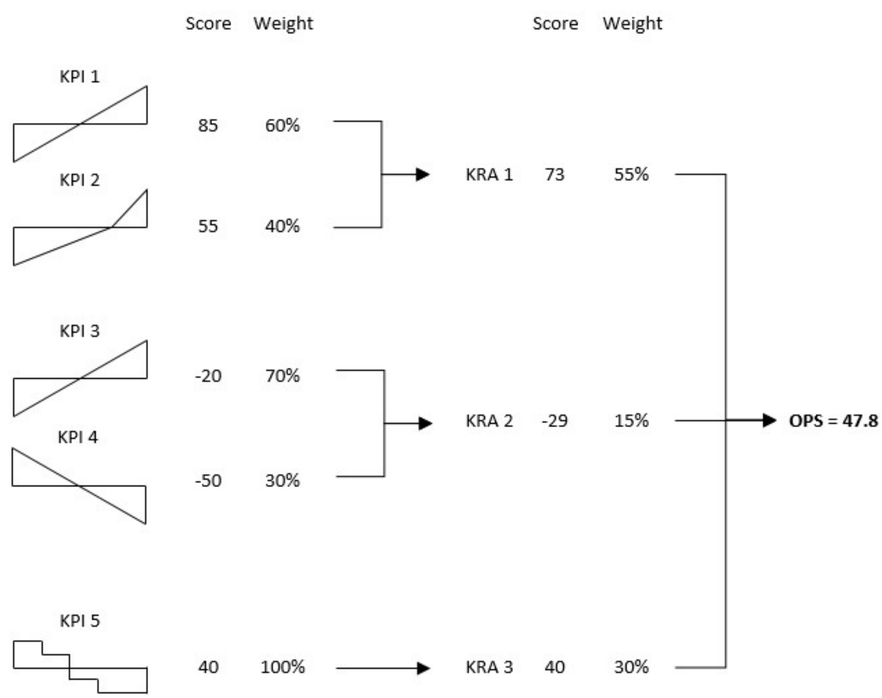

Figure 3-4. Relationship between the KPIs, KRAs, and OPS.

Figure 3-5 provides an example of a schedule KPI. The schedule KPI may relate the days over/under the target schedule to a KPI score. An agreement between the client and NOPs will need to occur to set how many days over/under schedule will constitute exceptional and substandard performance. Figure 3-5 shows an example of a linear scale relating days early/late to its KPI score.

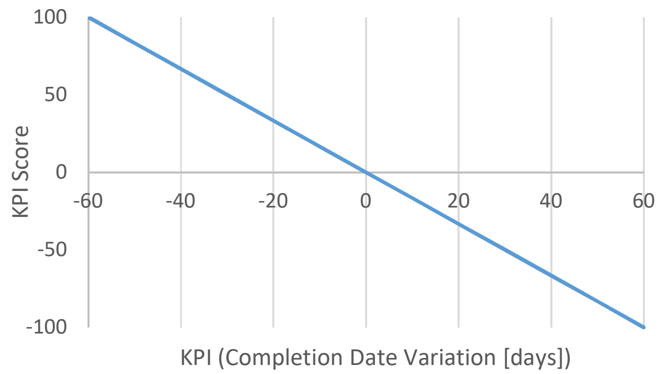

Figure 3-5. Example relationship between schedule KPI and KPI score.

Based on the OPS score, clients can use one or both of the following mechanisms to incentivize the achievement of their non-cost KRAs.

1. KRA Pool: The OPS score can be linked to a pool of funds (KRA Pool) that the owner will pay to the NOPs in the case of exceptional performance (OPS > 0), or the NOPs will refund the owners for substandard performance (OPS < 0). If the OPS exceeds zero, the owner will make an extra payment to the NOPs based on a linear scale up to an agreed maximum value. If the OPS is less than zero, the NOPs will refund the owner based on a linear scale up to an agreed maximum. A graphic representation of the KRA Pool mechanism is presented in Figure 3-6. Note, the KRA Pool maximum and minimum values do not need to be equal.

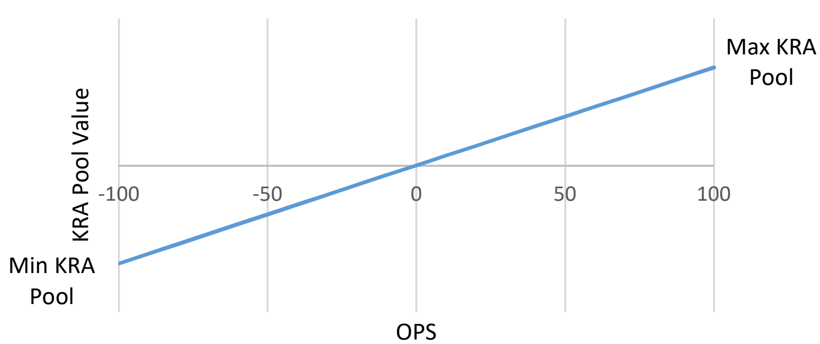

Figure 3-6. KRA Pool mechanism.

2. Pain/Gain Modifier: The OPS score can also be linked to adjust the cost over/underrun sharing ratio. In the instance of good performance in the non-cost KRAs (OPS > 0), NOPs can increase their share of underruns or decrease their allocation of overruns. Alternatively, in the case of poor non-cost performance (OPS < 0), NOPs will reduce their share of underruns and increase their allocation of overruns. The Department of Treasury and Finance of Victoria suggests the OPS score should adjust the cost over/underrun sharing agreement by +/- 20% (DTF Victoria, 2006). A graphic example of a +/-20% pain/gain modifier is presented in Figure 3-7.

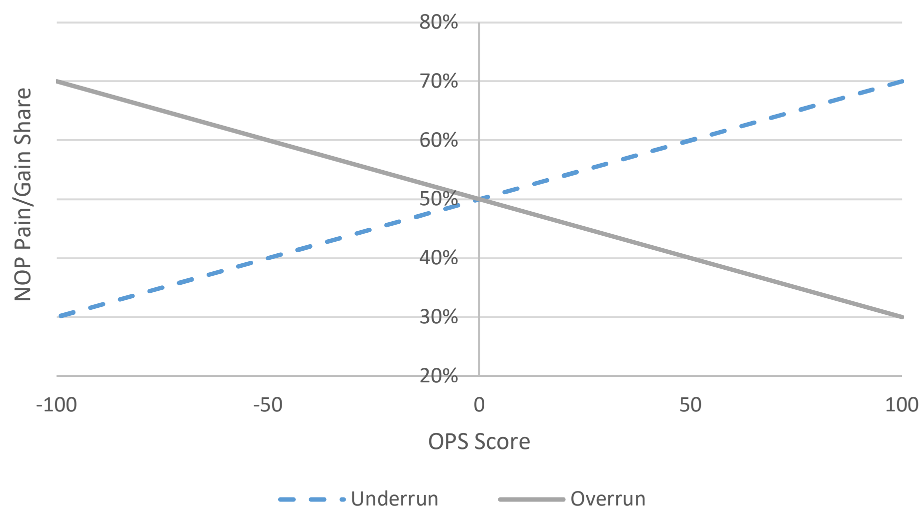

Figure 3-7. +/- 20% Pain/Gain modifier example.

Limb 3 Summary

The previous section has shown that there are various mechanisms that clients can use to tie compensation to project performance. Figure 3-8 was developed to help visualize how each of these mechanisms work together to determine the final Limb 3 value.

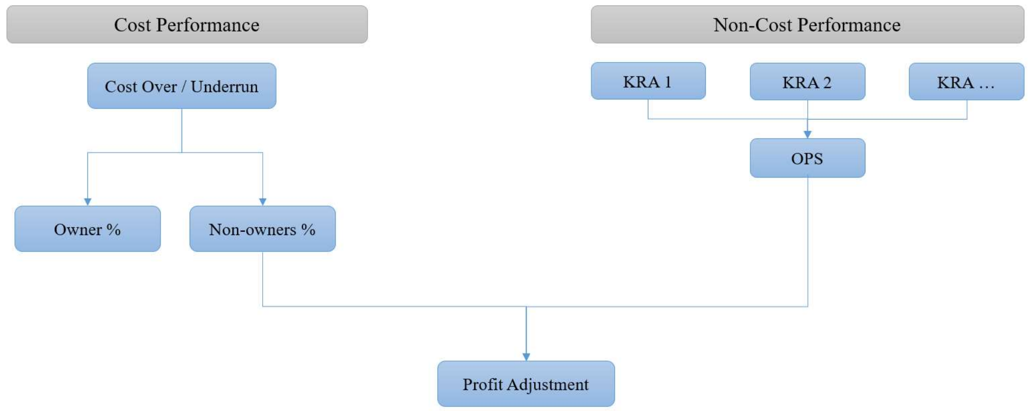

Figure 3-8. Visualization of the different incentive mechanisms in the Limb 3 component.

3.3 Methodology

Creswell and Poth (2018) explain that, "we conduct qualitative research because a problem or issue needs to be explored… we also conduct qualitative research because we need a complex, detailed understanding of the issue. This detail can only be established by talking directly with people". The objective of this paper is to explore the lessons from practitioners on the components of the shared risk/reward commercial terms. This objective is exploratory by nature and a qualitative methodology was deemed most appropriate to capture the nuances associated with this topic. Another motivating factor for using a qualitative approach is that it allows for clarification of questions to ensure the participants fully understand the questions being asked. This is particularly important when discussing these detailed commercial terms. The qualitative approach enabled the researcher to provide real time clarification of the questions which would not have been available through more traditional quantitative approaches.

Data for this paper was collected through seven semi-structured interviews. Data collection for this paper was coordinated with the qualitative data collection of

Chapter 2. For information about the interview participants and the population sampling procedure, see Section 2.4. Following the questions asked in relation to Chapter 2, the interviewees were asked specific questions about the shared risk/reward commercial model. The Limb 3 component of the shared risk/reward model was separated into two mechanisms: the cost performance mechanism, and the non-cost performance mechanism. For each mechanism, participants were asked if they thought it was beneficial to project outcomes and if there is anything that they would change in future agreements. Participants were also questioned on how they decided what parties would be included in the agreement. For the interview protocol, see Appendix B.

3.4 Results and Discussion

The objective of the interviews was to capture lessons about each component in the shared risk/reward commercial model. The findings are organized and presented by those related to the cost performance mechanism, the non-cost performance mechanism, and deciding who to include in the agreement.

3.4.1 Cost Performance Mechanism

Pain/Gain Sharing

All seven interviewees indicated that the pain/gain mechanism was the most important part of the commercial terms and the driver of different behavior. Participant G noted, "I think it's very critical. If you do not have that, you are not going to drive any change in behaviors because, at the end of the day, it is still a commercial arrangement. It is still a contract, and the objective of the NOPs is to make money". This finding is consistent with the results of Love et al, who also

reported that the “share in the profit/loss was a driving factor for collaborative behavior and achieving cost efficiencies” (Love et al., 2011).

The participants also appeared to believe that the pain/gain sharing mechanism was more influential than the non-cost mechanism. Most interviewees supported the use of the non-cost KPIs, but they were described as a nice to have and not essential. Participant C said, “They [non-cost KPIs] are important, and we want them, but they are more in the nice to have category”. Participant C also said, “I think the price mechanism [pain/gain mechanism] is definitely the big thing, because that allows you to build the project”.

NOP Risk Cap

The interviewees were asked for their opinion on the NOP risk cap. Participant D reported that while there can be good reason to implement this mechanism, it has its drawbacks. Participant D explained, “With caps, there is no incentive once the threshold is reached”. If a project enters painshare (limb 2 is totally exhausted), then a contractor can become unmotivated to perform. Participant D reported that in an alliance that was performing poorly, there was high turnover of key personnel from the contractor’s organization, making the project come to a halt. This concern was shared by Participants C and G, who also mentioned that they had experienced an alliance where most, or all, of the limb 2 fee was lost, and that created situations where the contractor lost motivation. And once that happened the client really begun to suffer.

The interviewees revealed that capping the downside risk of NOPs can compound a client’s risk if the project becomes distressed. Not only must they absorb all cost

overruns after the Limb 2 fee is exhausted, but they will need to absorb the losses associated with the contractor losing interest in the project.

When asked what they would do differently, Participant D proposed, “rather than having caps, perhaps risk and profit should be shared 50/50 to a point and then apply a diminished risk and profit share”. For example, clients and NOPs could share pain/gain at a 50:50 split up to the Limb 2 fee, and any further pain/gain could be split 85:15 between the client and NOPs, respectively. Figure 3-9 depicts the proposed model. Participant C, another client representative, was presented this alternative model. Participant C indicated that, while this had never been discussed, it made good logical sense to have the same sharing relationship between the gain and pain sides. Participant C did raise a concern about this proposed model, saying, “as soon as you put the direct cost of the NOPs at risk, they will build contingency into their limb 1 fee”. This is a fair critique of the alternative pain/gain sharing model and shows that decisions relating to the risk cap mechanism require a trade-off.

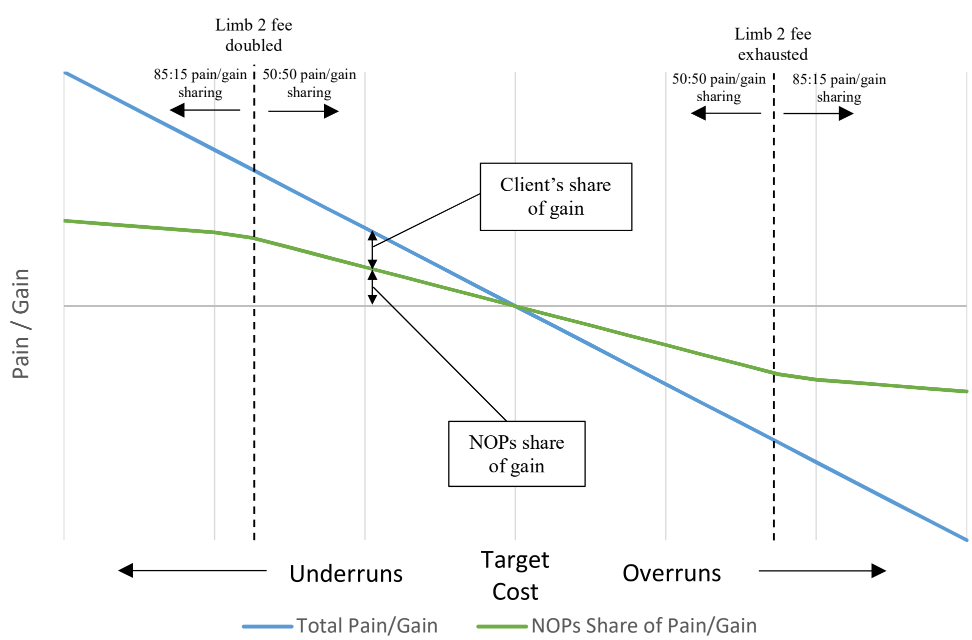

Figure 3-9. Proposed pain/gain share arrangement.

One of the criticisms of the shared risk / reward commercial model is that it incentivizes parties to inflate their target cost (Henneveld, 2006; Thomsen et al., 2016; P. Wood & Duffield, 2009). Another attractive quality of the proposed model for sharing cost over/underruns is that the higher percentage of retained savings for the owner would protect them from cases where the target cost was excessively inflated.

3.4.2 Non-Cost Performance Mechanism

KPIs

Interviewees were asked if there was anything they would change about the non-cost KPIs that were included in their contracts. Participants B and G explained that their non-cost KPIs actually did change during the course of their projects' execution. Participants B and G revealed that their contracts contained provisions that enabled the KPIs to be reviewed. Participant G reported that they were involved in an alliance were the KPIs were reviewed every six months, and the alliance management team had the opportunity to change the KPIs. Participant G revealed that the management team did change KPIs some of the KPIs because the original KPIs were not providing proper representation of the performance of the project. In other words, the OPS indicated the project was more successful that what the management team believed, and the provision enabled them to fix that.

KRA Pool

All seven participants stated that there was a minimum KRA Pool value that was needed to incentivize the NOPs to pursue them. However, no participant could identify a policy or rule of thumb for what this minimum should be. Participant C said, "It has to be a meaningful amount of money, otherwise they [the NOPs] will not

put any effort into achieving it". In the study by Love et al. (2011), they observed that alliance KRA Pools ranged from 0.55 – 3.6% of the total project value.

Participant C noted, in their experience, the KRA pool usually is limited by political reasons. Participant C reported that, in an alliance that is about to be tendered, local Politian's view the KRA Pool as a completion bonus, and do not support the KRA Pool. Participant C suggested that a client could ask themselves, "How much can you include in the KRA pool and reasonably justify, then take a critical look at whether that amount would incentivize you to chase it". It was also recommended that clients use the tendering period to directly ask the NOPs if the value of the KRA Pool is sufficient to encourage them to pursue those outcomes.

3.4.3 Who to Include in the Agreement

Case studies on IPD projects have revealed that a wide range of parties have been included in the shared risk/reward commercial agreements (Cheng & Johnson, 2016). Some involve only the client, the prime contractor, and a prime architect/engineer; others include each of those as well as several key suppliers. The interviewees were asked what parties they viewed as being critical to include in the agreement. Participant D said, "You must consider which participants have an interest in the risks and the ability to influence outcomes". This sentiment was echoed by all participants, suggesting that it would change for every project.

Three of the Participants (C, F, and G) reinforced the importance of this issue by presenting cases where the exclusion of key contractors or suppliers from the agreement led to poor project outcomes. Participant F gave an example of a steel supplier who was not included in the commercial terms and indicated this was a mistake because the steel work ended up delaying the overall project. Had their profit

been at risk of the overall project, Participant F contended that they would have given the project more attention.

Participant G also gave an example of an alliance where the earthworks subcontractor was not included in the main alliance agreement. Instead, the prime contractor entered into a sub-alliance agreement with the earthwork subcontractor. A sub-alliance agreement contains many of the same provisions as a main alliance but is between a main alliance participant and one of their sub-contractors, and only for a specific scope of work. Participant G believed that the decision to use a sub-alliance was the leading reason why the project failed to meet both time and cost targets. They explained that the sub-alliance caused the culture to effectively revert to the fragmented and self-interested environment found on traditional contracts. This was because the sub-alliance contractor's compensation was no longer tied to the overall project's performance; instead, their compensation was in relation to the completion of their specific scope of work. This reportedly reduced their willingness to collaborate with other parties, and this unwillingness greatly impacted other critical parts of the project, extending the project's completion date by over 25%. Figure 3-10 shows a graphical representation the problem experienced on this project.

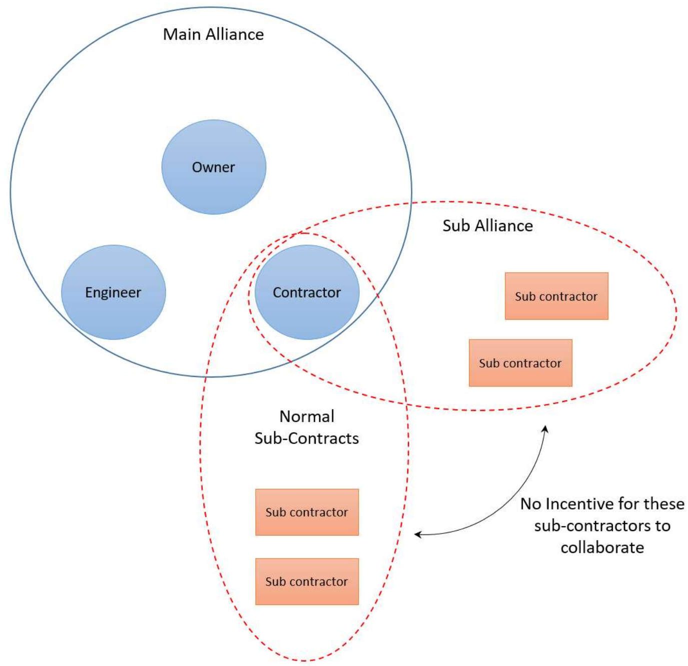

Figure 3-10. Depiction of sub-alliance contractor unwilling to collaborate with other subcontractors.

When asked how a client should determine who to include in a collaborative agreement, none of the interviewees could identify a formal process. Participant G noted that there is an important difference depending on how the project is tendered. Under a non-price model, the client selects which contractor and engineer to engage with. In this case, the client has full control over which parties to include in the agreement and needs to use their best judgement. In contrast, under a competitive model, the client releases an RFQ/RFP, and a consortium of contractors and engineers respond to that RFQ/RFP. Under the competitive model, the client leaves the decision of who to include in the shared risk/reward agreement up to the organization leading the consortium.

This distinction is important because Participant G suggested that clients who competitively tender their collaborative agreements are leaving the critical decision of who to include in the agreement up to another party. As described above, failing to

include key contractors and suppliers has led to poor outcomes, so it should be in a client's interest, regardless of tendering method, to have a say in who is part of the agreement.

3.5 Conclusions

The shared risk/reward commercial terms are complex, and it is challenging for clients to understand the implications of each of its components. To address this issue, this paper explored lessons from clients that currently implement these unique commercial terms. The key lessons learned include the following:

1. The pain/gain sharing mechanism is the primary driver of more collaborative behavior. The non-cost KRAs are "nice to have" but are less influential than the pain/gain mechanism.
2. If a project enters painshare and the risk cap threshold is reached, the contractor may lose motivation to perform. Clients may want to consider alternative risk capping arrangements to ensure contractors will remain engaged regardless of the state of the project.
3. Contract provisions that enable management to review KPIs are an effective approach to ensure that the KPIs reward the project team for above average performance.
4. A minimum KRA Pool is necessary to incentivize the project team to pursue those non-cost outcomes.
5. Excluding key contractors or suppliers from the commercial agreement can result in poor project outcomes.
6. Using sub-alliances may lead to traditional fragmented and adversarial behavior between the sub-alliance contractor and other project participants. Further investigation is required on the performance of sub-alliances.

4. CHAPTER 4 – FRAMEWORK FOR EVALUATING THE SUCCESS OF COLLABORATIVELY DELIVERED INDUSTRIAL PROJECTS

4.1 Introduction

As clients in the industrial sector begin adopting collaborative delivery methods there will be a need to evaluate if this delivery method provides superior outcomes to projects executed under traditional delivery methods. Currently, there are no frameworks that compare the performance of industrial projects that are executed under different delivery methods. The objective of this research is to develop a Project Success Framework (PSF) that will enable clients in the industrial sector to benchmark the performance of their traditional projects and make more informed decisions about the effectiveness of collaborative delivery methods in this sector.

Additionally, as shown in Chapter 3, the shared risk/reward commercial agreement uses non-cost KPIs to measure and incentivize performance. To achieve optimal performance of collaboratively delivered projects, it is important for project teams to clearly define, measure, and assess important performance outcomes. The PSF developed through this study is aimed to inform industrial project practitioners of metrics that can be used to incentivize high performance.

4.2 Background on Project Success

This problem is a subset of the topic of project success and how it should be measured. Bannerman (2008), Müller and Jugdev (2012), and Soon Han et al. (2011), have all identified that there are two distinct streams of research on project success: project success criteria, and project success factors. Project success criteria is research on how the success of a project is evaluated. Specifically, this refers to the information required to evaluate if a project was, or was not, successful. The second

stream of research relates to factors that affect the success of a project. This stream of research focuses on understanding why two different projects may have been delivered with different levels of success. The objective of this paper is to develop a framework to evaluate the success of an industrial project, so this literature review focuses on the first stream of research. The literature review begins with a review of the conceptual models of projects success and is followed by a review of the pragmatic approaches that have been taken to evaluate the success of construction projects.

4.2.1 Conceptual Models of Project Success

It would be difficult to find an article on the project success that does not mention cost, time and quality criteria. Most authors, including, but not limited to, Al-Tmeemy et al. (2011), Atkinson (1999), Baccarini (1999), Chan (2001), Lim and Mohamed (1999), Müller and Jugdev (2012), Pinto and Slevin (1988), each refer to these three criteria as fundamental to the evaluation of a project's success. These three criteria have become so deeply engrained in the understanding of project success that Atkinson coined them the "iron triangle". However, Atkinson suggests that the "iron triangle" is not wrong, but incomplete, and he suggests that reducing success to these three measures is akin to a Type 2 error. Atkinson presented his own interpretation of project success which consisted of two dimensions: the delivery stage, and the post-delivery stage. The deliver stage dimension relates to the traditional outcomes of meeting cost, time, and quality targets. The post-delivery stage dimension relates to providing benefit to the project stakeholders, ensuring users are satisfied with the product, and ensuring the outcome meets the needs of the customer.

Pinto and Slevin's seminal work on project success has helped people understand the importance of being able to evaluate a project's success (Pinto & Slevin, 1988). They explain that a project manager's bonuses, promotions, and overall career are often dictated by how "successful" they are in delivering of projects. Pinto and Slevin developed a conceptual model of project that success that had two primary dimensions: the project and the client. The project dimension relates to the project meeting cost, time, and quality targets. The client dimension relates to whether the project works and addresses a problem, to the satisfaction of the products users, and to whether the project will lead to more effective decision making.

Shenhar (1997) proposed that project success must be perceived in relation to four hierarchical dimensions. Dimension 1, Project Efficiency, relates to the traditional three criteria of success, cost, time, and quality. Dimension 2, Impact on the Customer, relates to the need for projects to serve their original purpose. Dimension 3, Business and Direct Success, relates to whether the project achieved its strategic goals. Dimension 4, Preparing for the Future, relates to how the project helped its organization prepare for future opportunities.

Lim and Mohamed (1999) proposed a conceptual model of project success for construction projects. They separated project success into a micro and macro viewpoint. The micro viewpoint is concerned with the results of the construction project at the end of the construction phase such as cost, time, quality, and safety. The macro viewpoint relates to whether or not the project fulfilled the needs of the user or stakeholders.

Baccarini (1999) separates project success into project management success and product success. Under Baccarini's model, project management success relates to the

project meeting its budget, schedule, quality. In a similar fashion to Lim and Mohammad's macro viewpoint, and Shenhar's business success dimension, Baccarini's product success relates to the extent to which the project satisficed the stakeholders needs and achieved its original purpose.

Each of the conceptual models of project success were summarized based on the outcomes that they deemed were necessary to achieve on a successful project. Table 4-1 presents this summary.

Table 4-1. Summary of the Conceptual Models of Project Success.

Outcome	Atkinson	Pinto and Slevin	Shenhar	Lim and Mohamed	Baccarini
Met cost objectives	x	x	x	x	x
Met schedule objectives	x	x	x	x	x
Met functional and technical requirements	x	x	x	x	x
Provided benefit to project stakeholders	x	x	x	x	
Users are satisfied with the product	x	x		x	x
Project outcome meets needs of the customer	x	x			x
Project increased organizational capability			x		
Project led to more effective decision making		x			
Project was delivered safely				x	

Bannerman (2008) explains that one of the challenges in determining if a project is successful is that one must first decide if a project is a means to an end, or if it is an end in itself. If a project is assumed to be a means to an end, then its performance should reflect how well the project achieved its strategic goals and how well it met its end user's needs. Alternatively, if the project is considered an end, then its success can be determined at its closeout stage based on traditional characteristics such as time, cost, and quality. Bannerman suggests that a project fits into one category or the

other. However, the previously detailed frameworks from Baccarini, Lim and Mohamed, Shenhar, and Atkinson, each suggest that a successful project is one that is successful as an end itself, as well as a means to other strategic and client ends.

4.2.2 Pragmatic Approaches

The aforementioned conceptual models provide insights to the range of outcomes that a project must achieve to be an overall success. However, each of them fails to provide measurement of the key project outcomes. Cost and time are usually defined as whether or not the project met its budgeted cost or planned duration, but the other criteria, such as the benefit to project stakeholders, are often provided with no specific measurable item. Other researchers have taken more pragmatic approaches to the measurement of a construction projects success. These are discussed below.

The KPI Working Group (2007) provides a two-step framework for measuring the success of a civil construction project. The two-step framework consists of Key Result Areas (KRAs), which are key outcomes that a project must achieve, as well as Key Performance Indicators (KPIs), which are specific measurable outcomes that are used to evaluate the performance in each KRA. The KPI Working Group provides six KRAs that define the success of civil infrastructure projects. The six KRAs and their definitions are shown in Table 4-2.

The KPI Working Group provides a range of KPIs that are used to measure each of the KRAs. The KPIs and their method of measurement can be found in Appendix G. Franz (2014) also used a two-step framework to defined the success of building projects. He defined success using cost, schedule, and quality KRAs, and provided specific KPIs to measure each of them. Franz's KPIs are shown in Appendix G.

Table 4-2. The KPI Working Group's KRAs and their Definitions.

KRAs	Definition
Client Satisfaction	Measures how satisfied the client was with the quality of the finished product and the service (of the whole project team). Usually measured at or shortly after completion and handover
Defects	Measures the degree to which the completed facility was free from defects that impacted on the client. Usually measured at the point the project is offered for handover.
Cost	Measures how well out-turn costs compared with original estimates.
Time	Measures how closely the project was delivered to the original timetable
Safety	A measure of the number of Lost Time Incidents per 200,000 hours worked. Equivalent to 100 Full Time Equivalent (FTE) employees.
Profitability	Measures company profit before tax and interest as a percentage of sales.

El Asmar et al. (2016) developed the "project quarterback rating" (PQR) to represent the success of building projects. The PQR is an aggregated performance index from a linear weighted sum of KPIs and KRAs. The PQR consists of seven KRAs and multiple KPIs within each KRA. The model of the PQR is shown in Appendix G.

The Construction Industry Institute (CII) is a center for research and development for best practices in the capital projects industry. Several of CII's research teams have developed performance frameworks to validate their tools and findings. CII's Pre-Project Planning Research Team (RT-039) developed a success index that was a linear weighted sum of two KRAs and four KPIs (CII RT-039, 1994). RT-039's success index is shown in Table 4-3.

Table 4-3. RT-039's Project Success Index.

KRA	KPI	Measurement
Project Success	Budget Achievement	$\frac{Actual\ cost - Estimated\ cost}{Estimated\ cost}$
	Schedule Achievement	$\frac{Actual\ duration - Estimated\ duration}{Estimated\ duration}$
Operating Success	Design Capacity Attained	$\frac{Actual\ output\ rate - Estimated\ output\ rate}{Estimated\ output\ rate}$
	Plant Utilization	$\frac{\#\ days\ plant\ produces\ product\ in\ 6\ months}{182}$

4.3 Overall Methodology

This research used a sequential exploratory mixed method design to build and validate the PSF for industrial projects. This methodology was chosen for several reasons. First, the concept of project success is a complex phenomenon, and the exploration of complex phenomena is well suited to qualitative methods (Creswell & Plano Clark, 2018). Second, survey dominant research methods have several drawbacks in construction research, such as low response rates, long response times, and long development periods (Gibson & Whittington, 2010).

The PSF for industrial projects was developed through two phases. Phase A consisted of a research charrette that was used to develop the structure of the PSF. In Phase B, a focused survey was developed and used to validate the PSF framework. The details of each phase are provided below.

Throughout the course of this study, CII's research team RT-383 helped to guide the direction of this research. This advisory group of practitioners consisted of 9 core members (4 client/owners, 1 contractor, 3 consultants, and 1 supplier), who are hereinafter referred to as the "research team". The knowledge of the research team was leveraged for the development of the framework, and the research team members were critical in the distribution and completion of the targeted survey.

4.3.1 Phase A: Research Charrette

An increasingly common research method in construction research in the structured workshop or "research charrette" (Gibson & Whittington, 2010). According to Gibson and Whittington (2010), research charrettes are an effective exploratory technique as they combine the best tenets of surveys, interviews, and focus groups in an accelerated time frame. Research charrettes have also been successfully used in a

variety of other exploratory construction studies, including Esmaeili et al.'s (2013) study of project success for building projects, and in the development of the PDRI for building projects (Cho & Gibson, 2000). For these reasons, a research charrette was deemed an effective approach to exploring the complex and multidimensional topic of evaluating the success of an industrial project.

As Gibson and Whittington explain, the construction industry typically does not permit probabilistic sampling because it is logistically impossible to define a sample frame. Therefore, the purposive sample of participants for the research charrette consisted of the research team members, as well as other industrial sector senior managers that were invited by the chair of RT-383's research team. There were 12 total participants, with 5 client representatives, 4 consultants, and 3 academics.

On June 18, 2019, a three-hour long research charrette was held to develop the KRAs and KPIs which would form the PSF. The research charrette was held in Lincoln, Nebraska. Participants were first refreshed on the objective of the workshop and the relationship between the KRAs, KPIs, and project success. CII's RT-341 completed a literature review to identify common Key Result Areas (KRAs) that have been used to define the success of construction projects (CII RT-341, 2019). This work was used as the starting point for the group discussion and participants were given a printed list of the 14 KRAs identified by RT-341. Each KRA was discussed as it relates to the evaluation of the success of an industrial project. A group consensus was required to include any of the KRAs in the final framework. To help participants conceptualize the KRAs, they were given the following instruction:

"If you were an owner and had to demonstrate that project A was more successful than project B, what are the areas that you would discuss?"

After the KRA task was completed, the group discussed KPIs that are representative of each of the KRAs. To help facilitate the discussion, each participant was given a list of KPIs that have previously been used to measure success on research projects. The participants of the research charrette were instructed that the KPIs must be measurable and accessible across all types of industrial projects. Similarly to the KRAs, a consensus among the group was required to include any KPI in the final framework. Notes were taken during the charrette, and then the framework was created in a Microsoft Excel Spreadsheet. Once the spreadsheet was finalized it was distributed to the research team for review.

4.3.2 Phase B: Validation Survey

To validate the relationship between the KPIs and KRAs, and to ensure these metrics are measurable across different projects, a targeted survey was developed. This survey asked respondents to categorize each KPI into one of the KRAs. If the KPI is categorized with the same KRA that was developed during the research charrette, there would be good indication that the KPI is representative of that key area of project success. A web-based questionnaire was developed in Qualtrics, and each member of the research team was instructed to send it to 10 people in their professional network. Definitions of each KPI and KRA were provided to respondents as downloadable pdfs to assist with their response. To mitigate the effects of order bias, the list of KPIs were randomly displayed to each participant.

4.4 Results

The objective of this paper was to develop a framework that would allow clients in the industrial sector to compare the performance of a collaboratively delivered project, with a project that was delivered under traditional delivery methods. The

results from the research charrette are provided first, and then the results of the targeted survey are presented.

4.4.1 Qualitative Research Charrette Results

The first objective of the research charrette was to finalize a comprehensive list of KRAs that can be used to compare the success of an industrial project executed under different delivery methods. Figure 4-1 shows the 11 KRAs that participants from the research charrette decided would be important to compare.

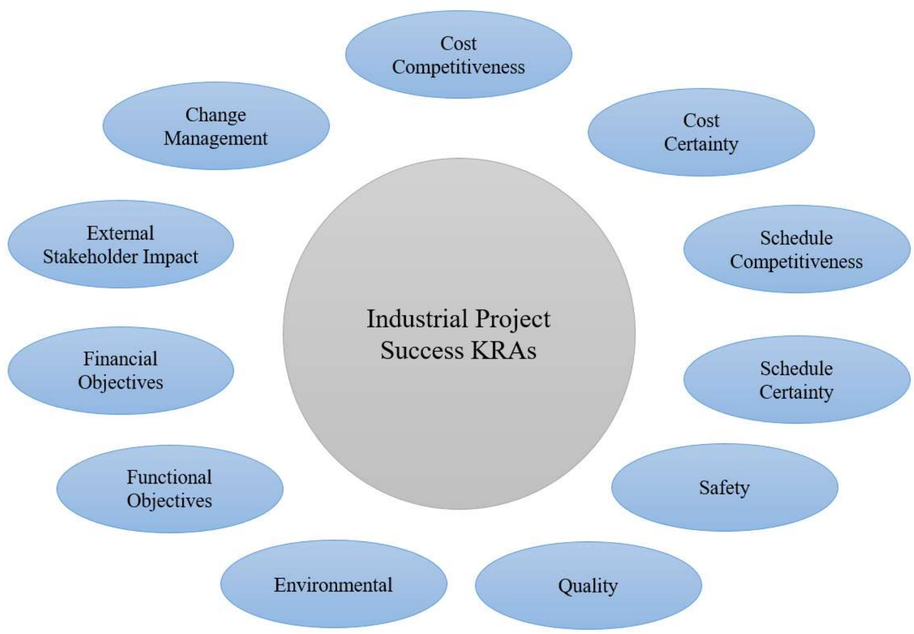

Figure 4-1. The 11 KRAs that shape the success of industrial projects.

Definitions for each of the final 11 KRAs developed during the research charrette are presented in Table 4-4.

Table 4-4. Definition of the 11 KRAs for Industrial Projects.

KRA	Definition
Cost Competitiveness	This construct represents a measure of how competitively the project was priced compared to the typical market conditions at the time the project was delivered. The objective of this KRA can be thought of as capturing the "value for money" that the owner receives.
Cost Certainty	Cost certainty represents a measure of how well the project's actual costs met the project's early cost targets.
Schedule Competitiveness	Schedule competitiveness is a measure of how competitively the project's schedule was compared to typical market conditions at the time the project was delivered.
Schedule Certainty	Schedule certainty represents a measure of how well the project's actual schedule met the project's early schedule targets.
Quality	Quality represents a measure of how well the project's products and services complied with its plans and specifications. This is not to be confused with the quality of the finishes used on the project.
Safety	Safety represents a measure of the frequency of recordable safety incidents that occurred on the project.
Project Functional Objectives	A projects functional objectives is a measure of how well the project achieved the client's functional objectives as defined in the client's business case that was used to justify the project's funding.
Project Financial Objectives	Financial objectives is a measure of how well the project achieved the financial objectives of all of the major participants in the project (typically the client, contractor, and engineer).
External Stakeholder Impacts	External stakeholder impacts is a measure of how much the execution of the project impacted external stakeholders. External stakeholders can include the public, the client's end users, or the client's internal operations.
Environmental Impacts	Environmental impacts is a measure of the frequency and magnitude of recordable environmental events that occurred on the project.
Change Management	The change management construct represents a measure of the frequency, size, and duration of changes that occurred on the project.

Client satisfaction was one of the 14 KRAs that was discussed by the team during the research charrette, but in contrast to popular trends in project success literature, was not included in the final framework. One of the participants during the research charrette said:

"if we delivered a project and it met all of the other KRAs, our organization would continue to do business with that service provider, regardless of our personal relationship"

There was consensus among the participants on this perspective. The group argued that, if a project met all of the other KRAs, then their clients would be satisfied and this would be redundant, so this KRA was removed from the final framework.

After the KRAs were finalized, the group identified KPIs that would be representative of the high order KRAs. The original list of KPIs developed during the research charrette is shown in Appendix H.

4.4.2 Validation of the KPIs

To validate that the KPIs are representative of their higher order KRA, a targeted survey was distributed to professionals in the industrial sector asking them to categorize each KPI into its respective KRA. After data cleaning, a total of 41 responses were received. The respondents' average number of years of experience was 21.5 years, with a standard deviation of 11.3 years. The sample population represented 21 clients, 10 contractors, and 10 engineers/consultants. 32 respondents primarily worked in the heavy industrial sector, 5 in the light industrial sector, 4 in power, utilities and infrastructure, and one in the building sector.

Each respondent was asked to categorize the list of KPIs into one of the 11 KRAs. Table 4-5 presents each KPI, the KRA it was categorized into during the research charrette (expected), and the KRA that was categorized most frequently in the targeted survey. Table 4-5 also indicates if there was a match between the expected and found KRA categorization.

Table 4-5. KPI Categorization from the Targeted Survey.

	KRAs		
KPIs	**Expected**	**Top Survey Categorization**	**Match**
Contingency Index	Cost Competitiveness	Cost Certainty	
Cost Efficiency	Cost Competitiveness	Cost Competitiveness	✓
Direct Work Rate	Cost Competitiveness	-	
Productivity	Cost Competitiveness	Cost Competitiveness	✓
Contingency Used %	Cost Certainty	Cost Certainty	✓
Cost Variation	Cost Certainty	Cost Certainty	✓
Buffer Index	Schedule Competitiveness	Schedule Certainty	
Time per Unit	Schedule Competitiveness	Schedule Competitiveness	✓
Schedule Variation	Schedule Certainty	Schedule Certainty	✓
Construction Defects	Quality	Quality	✓
Design Defects	Quality	Quality	✓
Non-conformance reports	Quality	Quality	✓
Quality Performance Rating	Quality	Quality	✓
Commissioning Time	Quality	Schedule Certainty	
DART Rate	Safety	Safety	✓
TRIR	Safety	Safety	✓
Goal Achievement	Project Functional Objectives	Project Functional Objectives	✓
Contractor Financial Objective Realization	Project Financial Objectives	Project Financial Objectives	✓
Owner Financial Objective Realization	Project Financial Objectives	Project Financial Objectives	✓
Complaints	External Stakeholder Impact	External Stakeholder Impact	✓
External Stakeholder Impact	External Stakeholder Impact	External Stakeholder Impact	✓
Notice of Violation	Environmental	-	
Recordable Environmental Events	Environmental	Environmental	✓
Change Cost Index	Change Management	Cost Certainty	
Change Time Index	Change Management	Change Management	✓
Non-owner Initiated Changes	Change Management	Change Management	✓
Owner Initiated Changes	Change Management	Change Management	✓
Speed of Change Approval	Change Management	Change Management	✓

Two of the KPIs (direct work rate and notice of violation) were categorized as “not important” by more than 15% of the respondents. Upon recommendations from the research team members, these two KPIs were removed from the PSF.

The final PSF for industrial projects is presented in Table 4-6.

Table 4-6. Project Success Framework for Industrial Projects.

KRAs	KPIs	Formula
Cost Competitiveness	Cost Efficiency	$\frac{Total\ project\ cost}{Capacity\ of\ facility^{a}}$
	Contingency Index	$\frac{Project\ contingency}{Total\ project\ budget^{b}}$
Cost Certainty	Cost Variation	$\frac{Actual\ project\ cost - Total\ project\ budget^{b}}{Total\ project\ budget^{b}}$
Schedule Competitiveness	Schedule Efficiency	$\frac{Total\ project\ duration}{Capacity\ of\ facility}$
	Buffer Index	$\frac{Project\ schedule\ buffer}{Predicted\ project\ duration^{c}}$
Schedule Certainty	Schedule Variation	$\frac{Actual\ project\ duration - Predicted\ project\ durationt^{c}}{Predicted\ project\ duration^{c}}$
Quality	QPR	$\frac{\sum N\ x\ w}{\#\ employee\ labor\ hours}\ x\ 200{,}000$
	Design defects	$\frac{Total\ \#\ of\ design\ errors}{Total\ \#\ of\ drawings}$
	Construction defects	$\#\ of\ punch\ items\ at\ mechanical\ completion$
	NCRs	$\#\ of\ non\ conformance\ reports$
	Commissioning duration	$Substantial\ completion\ - Mechanical\ completion$
Safety	TRIR	$\frac{\#\ OSHA\ recordable\ cases}{\#\ employee\ labor\ hours}\ x\ 200{,}000$
	DART	$\frac{\#\ DART\ incidents}{\#\ employee\ labor\ hours}\ x\ 200{,}000$
Project Functional Objectives	Goal Achievement	1-7 Likert scale: *This project achieved all of the functional objectives as set out in the projects business case*
Project Financial Objectives	Owner Financial Objective Realization	1-7 Likert scale: *This project achieved its financial objectives*
	Contractor Financial Objective Realization	1-7 Likert scale: *This project achieved its financial objectives*
External Stakeholder Impacts	Complaints	$\#\ of\ complaints\ received\ during\ the\ execution\ of\ the\ project$
	External stakeholder impact	1-7 Likert scale: *This project had minimal impact to its external stakeholders*
Environmental Impacts	Recordable environmental events	$\#\ of\ recordable\ environmental\ events$
Change Management	Change cost index	$\frac{Approved\ project\ development\ change\ costs}{Total\ project\ budget^{b}}$
	Change time index	$\frac{Approved\ project\ development\ change\ duration}{Predicted\ project\ duration^{c}}$
	# Non-owner changes	$\#\ of\ changes\ initiated\ by\ non-owner\ parties$
	# Owner Initiated changes	$\#\ of\ changes\ initiated\ by\ the\ owner\ /\ client$
	Speed of Change Approval	Average duration that RFIs are open in weeks
[a]The capacity of the facility should be a comparable industry metric for the facility (e.g. kWh, tonnes per day, bpd, etc.		
[b]The total project budget must include project contingency and be adjusted for scope changes.		
[c]The predicted project duration must include project buffers and be adjusted for scope changes.		

4.5 Discussion

The objective of this paper was to develop a framework that can evaluate the effectiveness of collaborative project delivery methods for industrial projects. 11 KRAs were defined as essential outcomes that can be used to define the success of an industrial project. Specific KPIs were also identified that can be used to consistently measure the performance of a project in each of the 11 KRAs. The PSF was designed to be flexible, so the KPIs that measure each KRA can change, enabling clients to replace them with metrics that are important to their specific project, sector, or business.

The KPIs also provide a specific way for clients to develop their non-cost incentive mechanisms in the shared risk/reward commercial model. One of the time-consuming activities associated with developing a collaborative contract is to identify suitable metrics to incentivize performance. The PSF provides clients with a "menu" of KPIs that can be used to develop these agreements.

4.5.1 Discussion of the KRAs

Two dimensions have consistently emerged from existing conceptual models of project success. The first dimension pertains to the success of the management of the project against predetermined targets: usually regarding cost, time, and quality. These outcomes can be evaluated immediately after the conclusion of the project. In Baccarini's terms, this is "project management success". The second dimension of success relates to how well the project fulfils the client's original need for the project. This type of success must be evaluated at some time after the delivery of the project and is referred to as "product success".

The 11 KRAs presented in the PSF can be separated into the project management and product success dimensions. The PSF contains 9 KRAs that relate to project management success and 2 KRAs that relates to product success, see Figure 4-2.

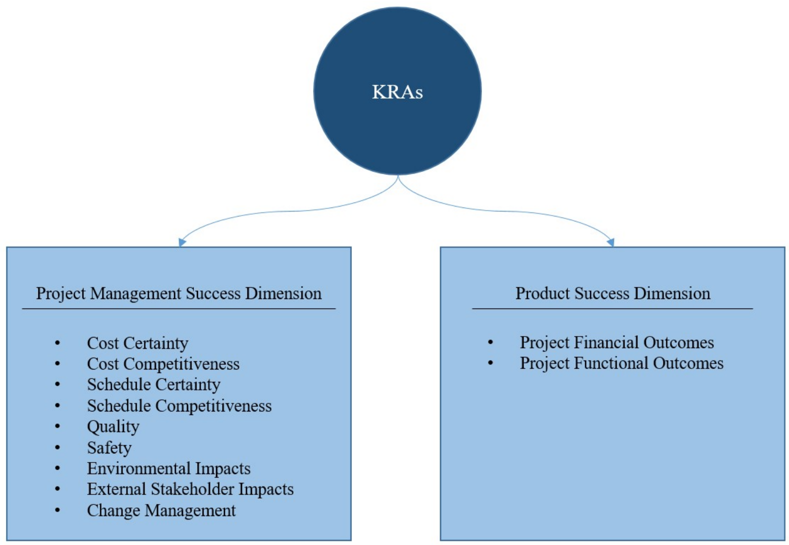

Figure 4-2. PSF KRAs separated into project management and product success dimensions.

As Figure 4-2 shows, the PSF places greater emphasis on outcomes in the project management dimension of overall project success. The PSF was developed with the purpose of comparing the success of projects delivered under different delivery methods. This indicates that project delivery methods have a greater influence over project management outcomes, rather than how well a project achieves its client's organizational needs. This makes intuitive sense, as a project delivery method is, in essence, the process by which a client realizes a project, not a way for clients to identify projects that will fulfil their organizational needs.

Baccarini states that a project's product success will trump its project management success (Baccarini, 1999). In practical terms, this means that projects that meet all their cost, schedule, and quality targets may still be considered a failure if they fail to

meet their client's long term organizational needs. Therefore, clients may be inclined to evaluate the performance of a delivery method based on a project's product success. Doing so would be a mistake, as the delivery method has limited influence over the project product success. This shows that clients need to consciously separate project management and product outcomes when evaluating the performance of a delivery method, and as Figure 4-2 shows, comparing delivery methods should focus on comparing project management outcomes.

The PSF presents an alternative approach for evaluating a project's cost and schedule performance. Typically, cost and schedule performance relate to a project's adherence to its target budget and target finish date. This success framework separates cost and schedule into their respective competitiveness and certainty. Practitioners provided this recommendation because they said a project's adherence to its targets is largely dictated by how competitive those targets are. For example, a project could be significantly under budget because of an inflated target budget. By separating a project's cost certainty from its cost competitiveness, clients gain a better understanding of how successful their project was.

Another reason for separating cost and schedule certainty from competitiveness is because it addresses an important criticism of collaborative delivery models. Under the shared risk/reward commercial model, non-owner parties share in the underruns of the project. This creates an implicit incentive to inflate the target cost (Henneveld, 2006; Thomsen, Darrington, Dunne, & Lichtig, 2016; Wood & Duffield, 2009). By separating cost certainty from cost competitiveness, clients can increase their visibility of the performance of a project and properly evaluate the effectiveness of the delivery method.

4.5.2 Discussion of the KPIs

The value of any comparison is dependent on the quality of information inputted into the analysis. One of the issues present with existing project success frameworks is that there is a lack of detailed instruction provided with their KPIs. For example, the traditional cost variation KPI is present in many existing project success frameworks (Chan, 2001; El Asmar et al., 2013, 2016; Franz, 2014; Hanna, 2016; KPI Working Group, 2007). In these frameworks, the cost variation KPI is typically defined as:

$$Cost\ Variation = \frac{Final\ Project\ Cost - Initial\ Budget}{Initial\ Budget}$$

The issue with this formula is that it does not inform the individual providing information on how to handle project change orders. Changes are a part of construction and will appear on every project. Changes will occur for a number of reasons, including differing ground conditions, inaccurate specifications, owner-initiated design changes, or errors and omissions in the drawings. The initial budget in this formula needs to reflect the cost of changes on the project. CII separates changes into two categories: project development changes and scope changes. Project development changes are defined as: “changes required to execute the original scope of work or obtain original process basis”. Scope changes are defined as: “changes in the base scope of work or process basis”. The PSF requires individuals to correct the initial budget for scope changes but not project development related changes. Doing so will better reflect the performance of the project team without distorting the cost information because of changes. Additionally, this will ensure that the project information being collected is consistent and thus will improve the accuracy of comparisons that can be generated from the framework.

The financial profitability indicator has been used a variety of existing frameworks; however, its previous appearances usually only refer to the profitability of the client (Chan, 2001; Nassar & AbouRizk, 2014). The PSF includes a KPI for the financial performance of the contractor. This indicator helps to identify if a project was more competitive because the work was delivered more efficiently, or if it was simply the result of contractors reducing their profit margins.

4.5.3 Implications for Practitioners and Researchers

The benefits of the PSF are threefold. As intended, it provides clients with a comprehensive list of KRAs and KPIs to compare the performance of a collaboratively delivered project with one that is delivered under traditional methods. This will enable clients to accurately evaluate the effectiveness of collaborative delivery methods for industrial projects.

The PSF will also enable clients to make more informed decisions about the application of all project delivery methods. Several efforts have been made to develop project delivery method selection tools, such as the CIIs "Project Delivery and Contracting Strategy" tool, and the United States Federal Highway "Contracting Alternatives Suitability Evaluator", but these tools continue to rely on judgement and subjectivity to make their evaluations. The PSF provides clients with a structured approach to evaluating the performance of their projects, and its adoption could help to create a database used to inform future delivery method selection tools based on sound empirical data, rather than subjective opinions.

Third, the PSF provides clients with a "menu" of KPIs that they can use to develop their shared risk/reward commercial models. Collaborative delivery methods provide clients with an opportunity to incentivize the achievement of their non-financial

objectives through KPIs. However, it can be challenging to measure performance in outcomes other than cost. The PSF provides clients with a range of KPIs as well as the KRA that they will each incentivize. This will help reduce the time spent negotiating the metrics within the commercial model and ensure that their commercial models incentivize behavior that promotes project success.

4.6 Conclusions

Collaborative project delivery methods are an outcome focused delivery method is being adopted with the intent to deliver high risk industrial projects more effectively. This paper developed and validated a Project Success Framework that will allow researchers and practitioners to empirically evaluate the effectiveness of collaborative delivery methods on important project outcomes for industrial capital projects. This PSF also provides a structured approach to compare the performance of any project delivery method across a varied spectrum of projects. Its adoption will enable organizations to develop more accurate project delivery method selection tools that use empirical evidence to determine when each delivery method would promote the optimal results. Lastly, this framework will help clients develop their shared risk/reward commercial models so that they incentivize behavior that promotes successful outcomes.

5. CHAPTER 5 – CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH

Collaborative delivery methods present a fundamentally new way for clients to deliver capital projects, and their recorded success on civil and healthcare projects has gathered the attention of the industrial sector. Prior research has found strong interest within the industrial sector for using a delivery system that is more collaborative and that aligns the commercial outcomes of all the participants (CII RT-271, 2012). To address this demand, this thesis provides three papers that each address an issue with the adoption of collaborative delivery methods in the industrial sector. In combination these papers will facilitate with the industrial sectors inevitable transition to collaborative delivery of their capital projects. The conclusions from each paper are presented below.

5.1 Conclusions

Existing knowledge on the types of projects that suit collaborative delivery methods lack definition and consistency. Chapter 2 brought much needed clarity to the body of knowledge on this topic. Interviews revealed that projects with high uncertainty in their outcomes are best suited for collaborative delivery. This was validated through a web-based questionnaire of industrial projects which found that projects with greater risk were employing more C.I. methods and principles. This understanding will help clients in the industrial sector identify projects that will have the greatest likelihood of being successful under this new delivery method.

Chapter 2 also found evidence to suggest that, unlike current guidelines recommend, a project's complexity is not a good indicator of its suitability for collaborative

delivery. The web-based questionnaire also revealed that industrial projects with higher dollar value employ more collaborative and integrated practices.

Chapter 3 presented a detailed overview of the shared risk/reward commercial model and explored the lessons learned about each of its components. The findings of the interviews revealed several lessons that will help clients in the industrial sector understand the implications of these commercial terms and help them to develop their own commercial agreements.

The adoption of collaborative project delivery methods in the industrial sector remains low, but there is significant interest to move in a more collaborative direction. As clients begin to experiment, there will be a need to evaluate the performance of projects delivered under collaborative systems to those delivered under traditional systems. Without the ability to make this comparison, there will be no compelling evidence to drive change throughout the sector. Chapter 4 addresses this need by developing a project success framework that gives clients a structured approach to comparing the performance of their industrial projects delivered under different delivery methods.

The project success framework identified the following 11 Key Result Areas that clients should evaluate when comparing the performance of projects delivered under different delivery methods:

1. Cost Certainty
2. Project Functional Objectives
3. Cost Competitiveness
4. Project Financial Objectives
5. Schedule Certainty
6. External Stakeholder Impact
7. Schedule Competitiveness
8. Environmental Impacts
9. Quality
10. Change Management
11. Safety

In addition to the KRAs, Chapter 4 presents a list of KPIs that can be used by clients to develop their shared risk/reward commercial model. This list of KPIs will ensure that clients are incentivizing behavior that supports their desired outcomes.

5.2 Limitations

The findings of this study are subject to several limitations. Those limitations include the following:

- In Chapter 2, no relationship was found between complexity or schedule compression and the number of C.I. methods and principles on industrial projects. It is possible that the operationalization of these variables introduced error into the analysis and confounded the results.
- The sample size of the semi structured interviews used in Chapter 3 was limited. However, the population of projects delivered under collaborative delivery methods is small, and the population of senior management that are familiar with the commercial terms is even smaller. Additionally, this sample size was similar to other construction management research where the population investigated is small (Beckman-Cross, 2016; Love et al., 2011).
- In Chapter 3, there was also no representation of practitioners that had experience with the IPD delivery method in the sample of interviewees. Collaborative delivery methods encompass the IPD delivery method and including a participant with IPD experience would have provided a more complete perspective.
- The project success framework was developed with the intent of being applicable to all industrial projects. There may be limitations to this

generalizability because the group of professionals used to develop the project success framework may not have been representative of the entire industrial sector. Additionally, there was no representation of contractors during the development of this framework. With that being said, contractors were part of the targeted survey which validated the framework, mitigating this limitation.

5.3 Directions for Future Research

The findings of Chapter 2 revealed that projects with high uncertainty in their outcomes are good candidates for collaborative delivery methods. Currently, there is no consistent approach to evaluate a project's uncertainty. Future research should develop a reliable measure of this variable because it will enable clients to consistently evaluate their projects suitability for collaborative project delivery.

Interviewees suggested that the source of uncertainty differs between projects in the civil and healthcare industries. Future research should compare the different sources of uncertainty between these industries as it could help to explain differences found between the IPD and alliancing agreements. Such a finding could help inform the optimal structure of collaborative agreements in the industrial sector.

This research was unable to conclude a minimum project value needed to support collaborative project delivery methods. One avenue for future research would be to compare how the costs vary between projects delivered with collaborative delivery methods to those delivered under traditional delivery methods. This may be able to reveal the cost of setting up and running a collaboratively delivered project and could help determine if a minimum project value is needed to support this delivery method.

A lesson learned identified in Chapter 3 was that the use of a sub-alliance was a leading reason for the failure of one alliance in New Zealand. More research is needed to inform project teams on the implications of entering a sub-alliance agreement.

Once the industrial sector has increased its adoption of collaborative delivery methods there will be a need to research and publish the performance of these delivery methods as they compare to traditional delivery methods, as this will help with the widespread adoption of this new delivery system. The project success framework can be used to help guide this research.

6. REFERENCES

6.1 Chapter 1

ADIRD. (2015). National Alliance Contracting Guidelines—Guide to Alliance Contracting. Australian Department of Infrastructure and Regional Development. Retrieved from https://www.infrastructure.gov.au/infrastructure/ngpd/files/National_Guide_to_Alliance_Contracting.pdf

AIA. (2007). Integrated Project Delivery: A Guide. American Institute of Architects. Sacramento, CA.

Barutha, P. J. (2018). Integrated project delivery for industrial projects. Iowa State University. https://lib.dr.iastate.edu/etd/16546

Beckman-Cross, T. R. (2016). Evaluating Alliance Non-cost Performance Measurement. University of Canterbury. Christchurch.

Chan, A. P. (2001). Framework For Measuring Success Of Construction Projects. CRC for Construction Innovation.

Changali, S., Mohammad, A., & van Nieuwland, M. (2015). The construction productivity imperative. Retrieved from https://www.mckinsey.com/business-functions/operations/our-insights/the-construction-productivity-imperative

Cheng, R. (2012). IPD Case Studies. Retrieved from https://conservancy.umn.edu/handle/11299/201408

CII RT-271. (2012). Starting From Scratch: A New Project Delivery Paradigm. Construction Industry Institute. University of Texas, Austin.

CII RT-341. (2019). Integrated Project Delivery for Industrial Projects. Construction Industry Institute. University of Texas, Austin.

Cohen, J. (2010). Integrated Project Delivery: Case Studies. American Institute of Architects. Retrieved from https://www.ipda.ca/site/assets/files/1111/aia-2010-ipd-case-studies.pdf

DBIA. (2015). Choosing a project delivery method: A design-build done right primer. Design Build Institute of America.

DTF Victoria. (2006). Project Alliancing Practitioners Guide. Department of Treasury and Finance, State of Victoria, Australia.

Egan, J. (1998). Rethinking Construction: The Report of the Construction Task Force. Constructing Excellence. Retrieved from https://constructingexcellence.org.uk/rethinking-construction-the-egan-report/

Engebø, A., Lædre, O., Young, B., Larssen, P. F., Lohne, J., & Klakegg, O. J. (2020). COLLABORATIVE PROJECT DELIVERY METHODS: A SCOPING

REVIEW. JOURNAL OF CIVIL ENGINEERING AND MANAGEMENT, 26(3), 278–303. https://doi.org/10.3846/jcem.2020.12186

Ernst and Young. (2014). Spotlight on oil and gas megaprojects. Retrieved November 22, 2019, from https://www.ey.com/GL/en/Industries/Oil---Gas/EY-spotlight-on-oil-and-gas-megaprojects

Farmer, M. (2016). Modernise or Die—UK Construction Performance. Construction Leadership Council.

Ferreira, M. L. R., & Rogerson, J. H. (1999). The quality management role of the owner in different types of construction contract for process plant. Total Quality Management, 10(3), 401–411. https://doi.org/10.1080/0954412997910

Fischer, M., Ashcraft, H. W., Read, D., & Khanzode, A. (2017). Integrating Project Delivery. John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119179009.ch17

Gransberg, D. D., & Jeong, H. D. (2019). A COMPARATIVE ANALYSIS OF ALLIANCING AND INTEGRATED PROJECT DELIVERY ON COMPLEX PROJECTS: PARALLEL SYSTEMS SHARING A COMMON OBJECTIVE. 6.

Gransberg, D. D., Scheepbouwer, E., Loulakis, M. C., National Cooperative Highway Research Program, Transportation Research Board, & National Academies of Sciences, Engineering, and Medicine. (2015). Alliance Contracting: Evolving Alternative Project Delivery (p. 22202). Washington, D.C.: Transportation Research Board. https://doi.org/10.17226/22202

Hayford, O. (2018). Collaborative Contracting. Price Waterhouse Coopers. Retrieved from https://www.pwc.com.au/legal/assets/collaborative-contracting-mar18.pdf

Jackson, B. J. (2011). Design-Build Essentials. Delmar: Cengage Learning.

KPMG. (2015). Climbing the Curve—Global Construction Survey 2015. KPMG International. Retrieved from https://assets.kpmg/content/dam/kpmg/pdf/2015/04/global-construction-survey-2015.pdf

Lahdenperä, P. (2012). Making sense of the multi-party contractual arrangements of project partnering, project alliancing and integrated project delivery. Construction Management and Economics, 30(1), 57–79. https://doi.org/10.1080/01446193.2011.648947

Latham, M. (1994). Constructing the team: The Latham Report. HMSO, London.

McKinsey & Company. (2017). MGI-Reinventing-construction-A-route-to-higher-productivity-Full-report.pdf. Retrieved from https://www.mckinsey.com/business-functions/operations/our-insights/reinventing-construction-through-a-productivity-revolution

Merrow, E. W. (2012). Oil and Gas Industry Megaprojects: Our Recent Track Record. Oil and Gas Facilities, 1(02), 38–42. https://doi.org/10.2118/153695-PA

Ross, J. (2000). Introduction to Project Alliancing. Project Control International Ltd.

Ross, J. (2003). Introduction to Alliancing. Project Control International Ltd. Retrieved from https://www.pcigroup.com.au/our-publications/

Thomsen, C., Darrington, J., Dunne, D., & Lichtig, W. (2016). Managing Integrated Project Delivery. Construction Management Association of America. Retrieved from https://www.leanconstruction.org/wp-content/uploads/2016/02/CMAA_Managing_Integrated_Project_Delivery_1.pdf

6.2 Chapter 2

ADIRD. (2015). National Alliance Contracting Guidelines—Guide to Alliance Contracting. Australian Department of Infrastructure and Regional Development. Retrieved from https://www.infrastructure.gov.au/infrastructure/ngpd/files/National_Guide_to_Alliance_Contracting.pdf

AIA. (2007). Integrated Project Delivery: A Guide. American Institute of Architects. Sacramento, CA.

Association for Project Management. (2012). APM Body of Knowledge (6th ed.). High Wycombe, Bucks, UK: APM Publishing.

CII RT-305. (2016). Measuring Project Complexity and Its Impact. Construction Industry Institute. University of Texas, Austin.

CII RT-341. (2019). Integrated Project Delivery for Industrial Projects. Construction Industry Institute. University of Texas, Austin.

CMAA. (2012). An Owners Guide to Project Delivery Methods. Construction Management Association of America.

Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research (Third Edition). Thousand Oaks, CA: Sage.

DBIA. (2015). Choosing a project delivery method: A design-build done right primer. Design Build Institute of America.

Department of Public Works, Queensland. (2008). Relational Procurement Options: Alliance and Early Contractor Involvement Contracts. Queensland Government Chief Procurement Office.

DTF Victoria. (2006). Project Alliancing Practitioners Guide. Department of Treasury and Finance, State of Victoria, Australia.

Fischer, M., Ashcraft, H. W., Read, D., & Khanzode, A. (2017). Integrating Project Delivery. John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119179009.ch17

Frame, S., Picarel-Pechdimaldjian, J., & Bartz, O. (2019). Guide to contract alliancing in construction. Arcadis.

Hale, D. R., Migliaccio, G. C., & Asce, M. (2009). Empirical Comparison of Design/Build and Design/Bid/Build Project Delivery Methods. 9.

Hayford, O. (2018). Collaborative Contracting. Price Waterhouse Coopers. Retrieved from https://www.pwc.com.au/legal/assets/collaborative-contracting-mar18.pdf

Henneveld, M. (2006). Alliance contracting—Removing the boundaries for infrastructure delivery. Presented at the Annual conference of the Transportation Association of Canada, Charlottetown, Prince Edward Island.

Kenig, M., Allison, M., Black, B., Burdi, L., Colella, C., Davis, H., … McKimmey, M. (2010). Integrated Project Delivery: For Public and Private Owners. National Association of State Facilities Administrators.

Kowalski, C. J. (1972). On the Effects of Non-Normality on the Distribution of the Sample Product-Moment Correlation Coefficient. Applied Statistics, 21(1), 1. https://doi.org/10.2307/2346598

Molenaar, K., & Franz, B. (2018). Revisiting Project Performance. Charles Pankow Foundation and Construction Industry Institute. Retrieved from https://www.pankowfoundation.org/02-18-revisiting-project-delivery-performance

NSW Department of Commerce. (2005). Procurement Methodology Guidelines. New South Wales Government.

Nunnally, J. C. (1978). Psychometric Theory (2nd ed.). New York: McGraw-Hill.

NZTA. (2019). Procurement Manual: For activities funded through the National Land Transport Programme. NZ Transport Agency.

Park, H.-S., Lee, D., Kim, S., & Kim, J.-L. (2015). Comparing Project Performance of Design-Build and Design-Bid-Build Methods for Large-sized Public Apartment Housing Projects in Korea. Journal of Asian Architecture and Building Engineering, 14(2), 323–330. https://doi.org/10.3130/jaabe.14.323

Ross, J. (1999). Project Alliancing in Australia. Project Control International Ltd.

Ross, J. (2003). Introduction to Alliancing. Project Control International Ltd. Retrieved from https://www.pcigroup.com.au/our-publications/

Sanvido, V., & Konchar, M. D. (1998). Project Delivery Systems: CM at Risk, Design-Build, Design-Bid-Build. Construction Industry Institute. University of Texas, Austin.

Thomsen, C., Darrington, J., Dunne, D., & Lichtig, W. (2016). Managing Integrated Project Delivery. Construction Management Association of America. Retrieved from https://www.leanconstruction.org/wp-content/uploads/2016/02/CMAA_Managing_Integrated_Project_Delivery_1.pdf

Wood, H., & Ashton, P. (2010). The factors of project complexity. In 18th CIB World Building Congress (Pp. 69-80). Retrieved from https://cris.brighton.ac.uk/ws/portalfiles/portal/362500/CIB+Paper+547.pdf

Wood, P., & Duffield, C. (2009). In pursuit of additional value: A benchmarking study into alliancing in the Australian Public Sector. East Melbourne: Dept. of Treasury and Finance.

Yeung, J. F. Y., Chan, A. P. C., & Chan, D. W. M. (2007). The definition of alliancing in construction as a Wittgenstein family-resemblance concept. International Journal of Project Management, 25(3), 219–231. https://doi.org/10.1016/j.ijproman.2006.10.003

Young, B., Hosseini, A., & Lædre, O. (2016). The Characteristics of Australian Infrastructure Alliance Projects. Energy Procedia, 96, 833–844. https://doi.org/10.1016/j.egypro.2016.09.145

6.3 Chapter 3

ADIRD. (2015). National Alliance Contracting Guidelines—Guide to Alliance Contracting. Australian Department of Infrastructure and Regional Development. Retrieved from https://www.infrastructure.gov.au/infrastructure/ngpd/files/National_Guide_to_Alliance_Contracting.pdf

AIA. (2009). Experience in Collaboration: On the Path to IPD. American Institute of Architects.

Cheng, R., & Johnson, A. (2016). Motivation and Means: How and Why IPD and Lean Lead to Success. Lean Construction Institute and Integrated Project Delivery Alliance. Retrieved from https://hdl.handle.net/11299/198897

CMAA. (2012). An Owners Guide to Project Delivery Methods. Construction Management Association of America.

Creswell, J. W., & Poth, C. N. (2018). Qualitative Inquiry and Research Design: Choosing Among Five Approaches (Fourth ed.). Thousand Oaks, CA: Sage.

DTF Victoria. (2006). Project Alliancing Practitioners Guide. Department of Treasury and Finance, State of Victoria, Australia.

Fischer, M., Ashcraft, H. W., Read, D., & Khanzode, A. (2017). Integrating Project Delivery. John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119179009.ch17

Gransberg, D. D., Scheepbouwer, E., Loulakis, M. C., National Cooperative Highway Research Program, Transportation Research Board, & National Academies of Sciences, Engineering, and Medicine. (2015). Alliance Contracting: Evolving Alternative Project Delivery (p. 22202). Washington, D.C.: Transportation Research Board. https://doi.org/10.17226/22202

Henneveld, M. (2006). Alliance contracting—Removing the boundaries for infrastructure delivery. Presented at the Annual conference of the Transportation Association of Canada, Charlottetown, Prince Edward Island.

Kenig, M., Allison, M., Black, B., Burdi, L., Colella, C., Davis, H., … McKimmey, M. (2010). Integrated Project Delivery: For Public and Private Owners. National Association of State Facilities Administrators.

Love, P. E. D., Davis, P. R., Chevis, R., & Edwards, D. J. (2011). Risk/Reward Compensation Model for Civil Engineering Infrastructure Alliance Projects. Journal of Construction Engineering and Management, 137(2), 127–136. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000263

Ross, J. (1999). Project Alliancing in Australia. Project Control International Ltd.

Ross, J. (2001). Introduction to Project Alliancing. Project Control International Ltd.

Ross, J. (2003). Introduction to Alliancing. Project Control International Ltd. Retrieved from https://www.pcigroup.com.au/our-publications/

Thomsen, C., Darrington, J., Dunne, D., & Lichtig, W. (2016). Managing Integrated Project Delivery. Construction Management Association of America. Retrieved from https://www.leanconstruction.org/wp-content/uploads/2016/02/CMAA_Managing_Integrated_Project_Delivery_1.pdf

Wood, P., & Duffield, C. (2009). In pursuit of additional value: A benchmarking study into alliancing in the Australian Public Sector. East Melbourne: Dept. of Treasury and Finance.

6.4 Chapter 4

Al-Tmeemy, S. M. H. M., Abdul-Rahman, H., & Harun, Z. (2011). Future criteria for success of building projects in Malaysia. International Journal of Project Management, 29(3), 337–348. https://doi.org/10.1016/j.ijproman.2010.03.003

Atkinson, R. (1999). Project management: Cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria. International Journal of Project Management, 17(6), 337–342. https://doi.org/10.1016/S0263-7863(98)00069-6

Baccarini, D. (1999). The Logical Framework Method for Defining Project Success. Project Management Journal, Volume 30, 25–32. https://doi.org/10.1177/875697289903000405

Bannerman, P. L. (2008). Defining project success. Retrieved from https://www.pmi.org/learning/library/defining-project-success-multilevel-framework-7096

Chan, A. P. (2001). Framework For Measuring Success Of Construction Projects. CRC for Construction Innovation.

Cho, C.-S., & Gibson, E. (2000). Development of a Project Definition Rating Index (PDRI) for General Building Projects. Construction Congress VI, 343–352. Orlando, Florida, United States: American Society of Civil Engineers. https://doi.org/10.1061/40475(278)38

CII RT-039. (1994). Analysis of Pre-Project Planning Effort and Success Variables for Capital Facility Projects. Construction Industry Institute. University of Texas, Austin.

CII RT-341. (2019). Integrated Project Delivery for Industrial Projects. Construction Industry Institute. University of Texas, Austin.

Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research (Third Edition). Thousand Oaks, CA: Sage.

El Asmar, M., Hanna, A. S., & Loh, W.-Y. (2013). Quantifying Performance for the Integrated Project Delivery System as Compared to Established Delivery Systems. Journal of Construction Engineering and Management, 139(11), 04013012. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000744

El Asmar, M., Hanna, A. S., & Loh, W.-Y. (2016). Evaluating Integrated Project Delivery Using the Project Quarterback Rating. Journal of Construction Engineering and Management, 142(1), 04015046. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001015

Esmaeili, B., Franz, B., Molenaar, K. R., Leicht, R. M., & Messner, J. (2013). A Review of Critical Success Factors and Performance Metrics on Construction Projects. 10.

Franz, B. W. (2014). Modelling the role of team integration and group cohesion in construction project performance. The Pennsylvania State University, Pennsylvania.

Gibson, G. E., & Whittington, D. A. (2010). Charrettes as a Method for Engaging Industry in Best Practices Research. Journal of Construction Engineering and Management, 136(1), 66–75. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000079

Hanna, A. S. (2016). Benchmark Performance Metrics for Integrated Project Delivery. Journal of Construction Engineering and Management, 142(9), 04016040. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001151

Henneveld, M. (2006). Alliance contracting—Removing the boundaries for infrastructure delivery. Presented at the Annual conference of the Transportation Association of Canada, Charlottetown, Prince Edward Island.

KPI Working Group. (2007). The New Zealand Construction Industry National Key Performance Indicators: Handbook and Industry Measures. Retrieved from https://ir.canterbury.ac.nz/handle/10092/11589

Lim, C. S., & Mohamed, M. Z. (1999). Criteria of project success: An exploratory re-examination. International Journal of Project Management, 17(4), 243–248. https://doi.org/10.1016/S0263-7863(98)00040-4

Müller, R., & Jugdev, K. (2012). Critical success factors in projects: Pinto, Slevin, and Prescott – the elucidation of project success. International Journal of Managing Projects in Business, 5, 757–775. https://doi.org/10.1108/17538371211269040

Nassar, N., & AbouRizk, S. (2014). Practical Application for Integrated Performance Measurement of Construction Projects. Journal of Management in Engineering, 30(6), 04014027. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000287

Pinto, J., & Slevin, D. (1988). Project success: Definitions and measurement techniques. Project Management Journal.

Shenhar, A. J. (1997). Mapping the dimensions of projects success. Project Management Journal.

Soon Han, W., Md Yusof, A., Ismail, S., & Choon Aun, N. (2011). Reviewing the Notions of Construction Project Success. International Journal of Business and Management, 7(1), p90. https://doi.org/10.5539/ijbm.v7n1p90

Thomsen, C., Darrington, J., Dunne, D., & Lichtig, W. (2016). Managing Integrated Project Delivery. Construction Management Association of America. Retrieved from https://www.leanconstruction.org/wp-content/uploads/2016/02/CMAA_Managing_Integrated_Project_Delivery_1.pdf

Wood, P., & Duffield, C. (2009). In pursuit of additional value: A benchmarking study into alliancing in the Australian Public Sector. East Melbourne: Dept. of Treasury and Finance.

APPENDIX A. IRB APPROVAL LETTER

University of Nebraska Lincoln

Official Approval Letter for IRB project #19809 - New Project Form

December 20, 2019

Philip Barutha
Durham School of Architectural Engineering and Construction
NH 113 UNL NE 685880500

Xavier Mckenzie Wood Aliberch
Durham School of Architectural Engineering and Construction
NH 113 UNL NE 685880500

IRB Number: 20191219809EX
Project ID: 19809
Project Title: Industrial Integrated Project Delivery

Dear Philip:

This letter is to officially notify you of the certification of exemption of your project for the Protection of Human Subjects. Your proposal is in compliance with this institution's Federal Wide Assurance 00002258 and the DHHS Regulations for the Protection of Human Subjects at 45 CFR 46 2018 Requirements and has been classified as exempt. Exempt categories are listed within HRPP Policy #4.001: Exempt Research available at: http://research.unl.edu/researchcompliance/policies-procedures/.

o Date of Final Exemption: 12/20/2019
o Review conducted using exempt category 2b at 45 CFR 46.104
o Funding (Grant congruency, OSP Project/Form ID and Funding Sponsor Award Number, if applicable): Construction Industry Institute

We wish to remind you that the principal investigator is responsible for reporting to this Board any of the following events within 48 hours of the event:
* Any serious event (including on-site and off-site adverse events, injuries, side effects, deaths, or other problems) which in the opinion of the local investigator was unanticipated, involved risk to subjects or others, and was possibly related to the research procedures;
* Any serious accidental or unintentional change to the IRB-approved protocol that involves risk or has the potential to recur;
* Any protocol violation or protocol deviation
* An incarceration of a research participant in a protocol that was not approved to include prisoners
* Any knowledge of adverse audits or enforcement actions required by Sponsors
* Any publication in the literature, safety monitoring report, interim result or other finding that indicates an unexpected change to the risk/benefit ratio of the research;
* Any breach in confidentiality or compromise in data privacy related to the subject or others; or
* Any complaint of a subject that indicates an unanticipated risk or that cannot be resolved by the research staff.

This project should be conducted in full accordance with all applicable sections of the IRB Guidelines and you should notify the IRB immediately of any proposed changes that may affect the exempt status of your research project. You should report any unanticipated problems involving risks to the participants or others to the Board.

If you have any questions, please contact the IRB office at 402-472-6965.

Sincerely,

Becky R. Freeman, CIP
for the IRB

University of Nebraska-Lincoln Office of Research and Economic Development
nugrant.unl.edu

NUgrant

APPENDIX B. INTERVIEW PROTOCOL

Hello, my name is Xavier Wood, and I am a master's student at the University of Nebraska-Lincoln. Thank you for taking the time to talk to me today about your experience with Alliancing. If there is any question that you do not feel comfortable answering, or that does not apply to you, just let me know, and we will move on.

As this is a research project, we do require you to provide informed consent. [Give them the informed consent form.] This form includes information about the project overall, potential risks, and rewards, and what will be done with the data. [Go over each section, if needed.] We plan to record this interview, for later transcription and analysis, so there is also a permission to record checkbox.

Do you have any questions for me?

1. Participant Information
    a. How many years' experience do you have in your industry?
    b. How many alliance projects have you executed / worked with?
    c. What is the role of your organization?
    d. What is your position in your organization?
2. This section seeks to understand what type of project would be a good candidate for collaborative project delivery. Four variables are discussed.
    a. Risk
        i. Literature often states that alliancing is good for projects with high risk
        ii. Do you agree?
        iii. If yes, what exactly is meant by the term risk?
        iv. [Present risk events and project risk concept] Does your conceptualization of risk relate to risk events or project risk?
        v. Are there specific risks that lend toward collaborative delivery?
    b. Complexity
        i. Literature often states that alliancing is good for projects that are highly complex
        ii. Do you agree?
        iii. If yes, what exactly do you mean by complexity?
    c. Tight time frame
        i. Literature often states that alliancing is good for projects with tight time frames

        ii. Do you agree?
        iii. Can you describe how alliancing reduces overall project delivery duration?
    d. Project Value
        i. Alliancing guidelines often recommend that this delivery method is reserved for projects over $100M.
        ii. Do you agree?
        iii. If yes, why must projects have a minimum value?

3. This section seeks to understand your experience with the shared risk/reward commercial model. Questions are asked about each component in the commercial model.
    a. Pain/gain
        i. Was the pain/gain mechanism a primary driver of different behavior?
        ii. How did the pain/gain compare to the non-cost KPIs in terms of how they changed behavior?
        iii. Is there anything you would change with the pain/gain mechanism?
    b. NOP risk cap
        i. What are your thoughts on capping NOPS downside risk?
        ii. Is there anything you would change with the NOP risk cap mechanism?
    c. KPIs
        i. Would you change any of the non-cost KPIs used on alliance projects you have been involved with?
    d. KRA Pool
        i. Is there a minimum value needed to incentivize NOPs to pursue the KRA pool?
    e. Who to include in the agreement
        i. What parties should be included in the shared risk/reward agreement?
        ii. How should a client decide which parties to include?

4. Do you know of any other individuals that would be willing to speak with me about their experience on the alliance delivery method?

Those are all the questions we have for you. Thank you again for speaking to me!

APPENDIX C. C.I. PRINCIPLES DEFINITIONS

Collaboration and Integration Principles	
Continuous communication and issue resolution	A set of procedures that aims for the team parties to communicate throughout the entire project and consists of identifying and resolving issues, action planning, and follow-up agreements.
Jointly developed and validated targets	A process that aims for the members on the project team to define and confirm project targets and objectives throughout the term of the project.
Access to shared information systems	A system setup to allow for sharing of project information such as documents and models.
Early involvement of stakeholders	A process that allows key parties such as the owner, contractor, engineer(s), and major subs to be present and involved from the earliest design phases of the project.
Collaborative and equitable decision making	A process that aims for all members on the project team to collaborate on all project decisions throughout the project and to have an equal opinion on such decisions.
Financial transparency among key participants	An agreement where financial information such as the project budget is shared among key project participants.
Shared risk and reward	A process that allows for team members to combine the risk and rewards of the project and incentivize collaboration in order to reach common project goals.
Relational contracting (multi-party agreement)	An agreement where there is one contract between the project team. The contract can include owner, architect, general contractor, and other parties that have a primary role in the project.
Negotiated risk distribution	A document that specifies that there should be no litigation or arbitration between key participants and failure of this is not entitled to incentives or reimbursement.

APPENDIX D. C.I. METHODS DEFINITIONS

Collaboration and Integration Methods	
Alternate Scheduling Method (Pull Planning)	A plan for executing a specific phase of a project by using a "pull" technique to determine project hand-offs. The plan is prepared through a conversation by the team responsible for doing the work. Work is planned at the request of a downstream customer.
Co-location (Big Room)	An organizational placement strategy where project team members are physically located close to one another to improve communications, working relationships, and productivity.
Constructability Planning in Design Phase	The optimal use of construction knowledge and experience in planning, design, procurement, and field operations in order to achieve overall project objectives by improving means and methods and enhancing design intent.
Formal Partnering and/or Team Building	A project-focused process that builds and develops shared goals, interdependence, trust, commitment, and accountability, and improves team members' problem-solving skills. Partnering can be further defined as a structured sequence of principles initiated at the start of the project, based on mutual objectives, that applies specific tools and techniques (e.g., conflict resolution techniques) to achieve the agreed-upon performance metrics of the project.
Front End Planning (PDRI)	The process of developing sufficient strategic information for owners to address risk and make decisions about committing resources to maximize the potential for a successful project.
Joint Risk Assessment Tool	It is used by the owner, contractor, and designer to collaboratively identify, evaluate, and estimate the levels of risks involved on a project and determine an acceptable level of risk.
Multi-party Agreement	An approach that uses one contractor for the entire project, often entered in by the owner, designer, general contractor, and any other party who may have a primary role in the project. Including all key participants in the contract and agreeing to the same terms and conditions enables participants to understand each other's roles, responsibilities, and risk.
Multi-party Project Management Team	The key decision-making body for the project, responsible for providing leadership and governance, ensures that the obligations of the participants are fulfilled and the owner's objectives are achieved
Mutual Liability Waivers	A contracting mechanism that intends to reduce liability exposure for key project stakeholders. Can include simple waivers of consequential damages to prevent the owner, contractor, or designer from seeking damages for delay, or can include a more comprehensive approach to include project performance, builder's risk, and third-party claims.
No Dispute Charter	An agreement that there should be no litigation or arbitration between key participants, and that project failure does not entitle any participant to reimbursement.
Preassembly or Modular Construction	The use of offsite construction to prepare elements of a structure, often as modules to be assembled on site. Includes all substantial construction and assembly components and areas of the finished project.
Quality Improvement Process	Often referred to as "Six Sigma," a quality process that uses techniques to eliminate process variation. A statistical measure used to measure the performance of processes or products against customer requirements.
Rapid Process Improvement Workshops	A lean tool commonly referred to as "Kaizen" during construction and design charrette during design. The workshop brings line workers into decision processes for improvements and focuses on making quick, feasible changes.
Contract Incentives (Shared Risk and Reward)	Incentives written in the contract combine the risks and rewards of all team members and incentivize the achievement of common project goals.

Standardized Design Techniques	An attempt to design elements of a facility in a consistent manner in order to promote repetition, increase productivity, and reduce field errors.
Design to Cost (Target Value Design)	It aims to increase the value delivered to the owner by collaboratively designing against a detailed estimate that is based on a given cost, often the owner's allocable cost. Ultimately, the design follows this allowable cost.
Use of Technology as an Integration Tool	A combination of the design, fabrication information, erection instructions, and project management logistics in one database. Provides a platform for collaboration throughout a project's design and construction. BIM is an example of how technology can be used to integrate project information.
Value Engineering	An organized approach to analyzing designed building features, systems, equipment, and material selections. Aims to achieve essential functions at the lowest lifecycle cost while remaining consistent with performance, quality, and reliability, and safety requirements.
Value Streaming Mapping	Mapping all steps in project delivery, including the flow of materials and information. Improves the production process by identifying unnecessary steps and improving the project team's understanding of the process.
Advanced Work Packaging	An overall process flow of all the detailed work packages. It is a planned executable process that encompasses the work on an engineering, procurement, and construction project, beginning with initial planning and continuing through detailed design and construction execution.
A3 Decision Making	Also referred as A3 problem solving, it is a structured problem-solving and continuous improvement approach. It provides a simple and strict procedure that guides problem solving by workers. The approach typically uses a single sheet of ISO A3-size paper.

APPENDIX E. RISK ITEM EXAMPLE RISKS

Risk Item	Specific Risk Events
Funding	• Inflation • Escalation of material prices • Change in project funding sources
Geotechnical and Subsurface	• Ground conditions different than what was anticipated • Unforeseen utilities discovered
Environmental	• Delayed permit approvals • Changes in environmental regulations • Protected flora and fauna
Design	• Design errors and omissions • Poor constructability of designs • Poor operational functionality of designs
Weather	• Adverse weather conditions
Construction	• Construction quality issues • Safety incidents • Low labor and equipment productivity • Low availability of skilled labor • Poor construction trade coordination • Inaccurate cost estimates • Low availability of equipment and materials
Scope Change	• Unanticipated design or engineering changes • Change order negotiations • Scope Creep
Political and Community	• Public groups opposed to project • Political groups opposed to project
Land Acquisition	• Delays in acquisition of land
Organizational	• Poor communication between key project participants • Loss of key project personnel • Financial failure of project participants

APPENDIX F. CII PROJECT SECTOR BREAKDOWN

Project Sector	Types of Projects
Heavy Industrial	• Upstream Oil and Gas • Refining and Petrochemical • Mining and Metals • Pulp and Paper • Power Generation • Gas Processing
Light Industrial	• Automotive Manufacturing • Pharmacy and Biotech • Consumer Products (Food and Beverage)
Infrastructure	• Power transmission • Pipelines • Transportation • Water and Wastewater
Buildings	• Healthcare • Commercial • Office • Schools

APPENDIX G. PREVIOUS MODELS OF PROJECT SUCCESS

KPI working group's model of success

KRA	KPI	Measurement
Client Satisfaction	Satisfaction with Product	1 – 10 Likert Scale
	Satisfaction with Service	1 – 10 Likert Scale
Defects	Impact of Defects at Handover	1 – 10 Likert Scale
Cost	Design Cost Growth	$\frac{Actual\ design\ cost - Estimated\ design\ cost}{Estimated\ design\ cost}$
	Construction Cost Growth	$\frac{Actual\ constr.cost - Estimated\ constr.cost}{Estimated\ construction\ cost}$
	Total Cost Growth	$\frac{Actual\ cost - Estimated\ cost}{Estimated\ cost}$
Time	Design Schedule Growth	$\frac{Actual\ design\ duration - Estimated\ design\ duration}{Estimated\ design\ duration}$
	Construction Schedule Growth	$\frac{Actual\ constr.duration - Estimated\ constr.duration}{Estimated\ construction\ duration}$
	Total Schedule Growth	$\frac{Actual\ duration - Estimated\ duration}{Estimated\ duration}$
Safety	Lost Time Incidents	$\frac{\#\ Lost\ Time\ Incidents}{\#\ employee\ labor\ hours} x\ 200{,}000$
Profitability	Project Profit	$\frac{Project\ Profit}{Contract\ Value} x\ 100$

Franz's model of project success

KRA	KPI	Measurement
Cost	Unit Cost	$\frac{Final\ project\ cost}{Facility\ size}$
	Cost Growth	$\frac{Actual\ cost - Estimated\ cost}{Estimated\ cost}$
	Intensity	$\frac{Unit\ cost}{Project\ duration}$
Schedule	Schedule Growth	$\frac{Actual\ duration - Estimated\ duration}{Estimated\ duration}$
	Delivery Speed	$\frac{Facility\ size}{Project\ duration}$
	Construction Speed	$\frac{Facility\ size}{Construction\ duration}$
Quality of Building Systems	Quality of envelope and structure	1 – 6 Likert Scale
	Quality of interior finishes	1 – 6 Likert Scale
	Quality of environmental systems	1 – 6 Likert Scale

Facility Turnover	Difficulty of facility start up	1 – 6 Likert Scale
	Number and magnitude of call backs	1 – 6 Likert Scale
	Operation and maintenance costs	1 – 6 Likert Scale

The model of project success developed by El Asmar et al.

KRA	KPI	Measurement
Customer Relations	Return Business	1 – 5 Likert Scale
	Claims	Binary scale
Safety	OSHA Recordables	$\frac{\#\ OSHA\ Recordable\ Incidents}{\$\ Construction\ work} x\ 1{,}000{,}000$
	Lost Time Injuries	$\frac{\#\ Lost\ Time\ Incidents}{\$\ Construction\ work} x\ 1{,}000{,}000$
Schedule	Construction Speed	$\frac{Facility\ size}{Construction\ duration}$
	Delivery Speed	$\frac{Facility\ size}{Project\ duration}$
	Intensity	$\frac{Project\ Value}{Duration}$
	Schedule Growth	$\frac{Actual\ duration - Estimated\ duration}{Estimated\ duration}$
Cost	Unit Cost	$\frac{Final\ project\ cost}{Facility\ size}$
	Cost Growth	$\frac{Actual\ cost - Estimated\ cost}{Estimated\ cost}$
Quality	Systems Quality	1 – 5 Likert Scale
	Deficiency Issues	1 – 5 Likert Scale
	Punchlist Items	1 – 5 Likert Scale
	Warranty Costs	0 – 2 Ordinal scale
	Cost of Latent Defects	Binary scale
Financial	Profit	0 – 3 Ordinal scale
Communication and Collaboration	RFIs	$\frac{\#\ RFIs}{\$\ Project\ value} x\ 1{,}000{,}000$
	RFI Processing Time	Average RFI processing time in weeks
	Rework	0 – 4 Ordinal scale
	Resubmittals	$\frac{\#\ Resubmittals}{\$\ Project\ value} x\ 1{,}000{,}000$

	Total Changes	$\frac{Cost\ of\ changes}{Project\ value}$
	Change Order Processing Time	Average change order processing time in weeks
	Percent Plan Complete Trend	-1 – 1 Nominal Scale

APPENDIX H. INITIAL LIST OF KPIS DEVELOPED DURING THE RESEARCH CHARRETTE

KRAs	KPIs	Formula
Cost Competitiveness	Cost Efficiency	$\frac{Total\ project\ cost}{Capacity\ of\ facility}$
	Direct Work Rate	$\frac{\#\ workers\ executing\ direct\ work}{Total\ \#\ of\ craft\ workers\ on\ project}$
	Productivity	$\frac{Total\ project\ billable\ hours}{Capacity\ of\ facility}$
	Contingency Index	$\frac{Project\ contingency}{Total\ project\ budget}$
Cost Certainty	Cost Variation	$\frac{Actual\ project\ cost - Total\ project\ budget}{Total\ project\ budget}$
Schedule Competitiveness	Schedule Efficiency	$\frac{Total\ project\ duration}{Capacity\ of\ facility}$
	Buffer Index	$\frac{Project\ schedule\ buffer}{Predicted\ project\ duration}$
Schedule Certainty	Schedule Variation	$\frac{Actual\ project\ duration - Predicted\ project\ durationt}{Predicted\ project\ duration}$
Quality	QPR	$\frac{\sum N\ x\ w}{\#\ employee\ labor\ hours}\ x\ 200{,}000$ Where, N = # of unplanned quality events (variation, defect or failure) W = weighted severity level of each event
	Design defects	$\frac{Total\ \#\ of\ design\ errors}{Total\ \#\ of\ drawings}$
	Construction defects	$\#\ of\ punch\ items\ at\ mechanical\ completion$
	NCRs	$\#\ of\ non\ conformance\ reports$
	Commissioning duration	$Substantial\ completion\ - Mechanical\ completion$
Safety	TRIR	$\frac{\#\ OSHA\ recordable\ cases}{\#\ employee\ labor\ hours}\ x\ 200{,}000$
	DART	$\frac{\#\ DART\ incidents}{\#\ employee\ labor\ hours}\ x\ 200{,}000$
Project Functional Objectives	Goal Achievement	1-7 Likert scale: *This project achieved all of the functional objectives as set out in the projects business case*
Project Financial Objectives	Owner Financial Objective Realization	1-7 Likert scale: *This project achieved its financial objectives*
	Contractor Financial Objective Realization	1-7 Likert scale: *This project achieved its financial objectives*

External Stakeholder Impacts	Complaints	$\# \; of \; complaints \; received \; during \; the \; execution \; of \; the \; project$
	External stakeholder impact	External stakeholders could include: local businesses in surrounding area, local residents, other divisions at a facility during a renovation.
Environmental Impacts	Recordable environmental events	$\# \; of \; recordable \; environmental \; events$
	EPA Notice of Violation	$\# \; of \; Notice \; of \; Violations$
Change Management	Change cost index	$\frac{Approved \; project \; development \; change \; costs}{Total \; project \; budget}$
	Change time index	$\frac{Approved \; project \; development \; change \; duration}{Predicted \; project \; duration}$
	# Non-owner changes	$\# \; of \; changes \; initiated \; by \; non - owner \; parties$
	# Owner Initiated changes	$\# \; of \; changes \; initiated \; by \; the \; owner \; / \; client$
	Speed of Change Approval	*# of days between RFI request and closure*