COLLABORATIVE PROJECT DELIVERY PRACTICES, GOAL ALIGNMENT, AND PERFORMANCE IN ARCHITECTURE, ENGINEERING, AND CONSTRUCTION PROJECT TEAMS

By

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ABSTRACT

COLLABORATIVE DELIVERY PRACTICES, GOAL ALIGNMENT, AND PERFORMANCE IN ARCHITECTURE, ENGINEERING, AND CONSTRUCTION PROJECT TEAMS

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The Architecture, Engineering, and Construction (AEC) industry is increasingly challenged with improving the efficacy of project team performance through collaborative working arrangements. Collaborative working arrangements such as integrated project delivery, design-build, and project partnering are all comprised of interorganizational project teams. These teams, according to relational governance theory, generally function with flexibility, solidarity, mutual respect, and openly share information. Recent research shows that collaborative and cohesive teams are perpetuated by strategies to facilitate team integration methods. Efficient knowledge sharing and processing systems, also called transactive memory systems (TMS), are integral to cohesive project teams and their tasks coordination. Although the AEC literature is widespread on the importance of team integration and cohesion, little emphasis is placed on the effects of goal alignment practices and its relationship to performance outcomes. Thus, this research aims to explore this relationship along with the moderating effects of TMS in the context of partnered-projects by investigating interorganizational AEC project teams.

Some goal alignment characteristics of partnered-projects are generally in the form of partnering workshops, establishing clear goals and objectives, and the early involvement of key stakeholders (e.g., owner, designer, contractor, subcontracts). The link between partnering practices and project success dominates AEC literature, yet the elements of partnering practice

should be examined separately. This research asserts collaborative project delivery practices affect goal alignment and performance in AEC project teams. Furthermore, this research points out how behavioral attributes (i.e., transactive memory systems) of partnered-project teams are important to successful project delivery on AEC projects.

To achieve the aim of this study, data were collected from six case study projects and 125 participants using web-based surveys. Project information was accessed via partnering documents collected from key project stakeholders. A mixed methods approach was followed where 1) Qualitative data were analyzed using content analysis and case study tactics including pattern-matching and cross-case synthesis; and, 2) Quantitative data were analyzed using confirmatory factor analysis and multivariate regression analysis.

The theoretical contribution resulting from this research help explain the variation in interorganizational project team performance by examining key behavioral attributes emanating from organizational theory. Researchers have alluded to cognitive behaviors and social norms as potential moderators between performance outcomes and collaborative project delivery approaches. This study takes a step further positing clear metrics to understand goal alignment and team dynamics via transactive memory systems. It espouses relational governance theory as explanatory for the unique dynamics underpinning team integration. Findings show maintaining goal alignment becomes problematic as the number of performance measures increases or when competing messages are sent. This is exacerbated when performance measures such disincentives are codified in contracts without subsequent incentive or rewards. Other results show transactive memory systems has a positive effect on individual performance.

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KEY TO ABBREVIATIONS

AEC	Architecture Engineering and Construction
AIA	American Institute of Architects
BEA	United States Bureau of Economic Analysis
BIM	Building Information Modeling
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CII	Construction Industry Institute
CM	Construction Management
CM/GC	Construction Management/General Contractor
DB	Design-build
DBB	Design Bid Build
DBE	Disadvantaged Business Enterprise
DOT	Department of Transportation
FA	Factor Analysis
FAST	Focused Action Strategic Team
GDP	Gross Domestic Product
IPD	Integrated Project Delivery
IPI	International Partnering Institute
IRB	Institutional Review Board
JV	Joint Venture
LBE	Local Business Enterprise

LPS	Last Planner System
MOT	Maintenance of Traffic
MRC	Multivariate Regression Correlation
OLS	Ordinary Least Squares
QA	Quality Assurance
QC	Quality Control
QO	Quality Oversight
RMSEA	Root Mean Squared Error of Approximation
SAS	Statistical Analysis Software
SEM	Structural Equation Modeling
SME	Subject Matter Expert
SMM	Shared Mental Model
TCE	Transaction Cost Economics
TMM	Team Mental Model
TMS	Transactive Memory Systems
US	United States

CHAPTER 1 INTRODUCTION

This chapter broadly covers current practices and dilemmas facing interorganizational architectural, engineering, and construction (AEC) project teams. Particularly, as they strive to align their goals and objectives while maximizing performance outcomes. The problem statement in Section 1.2 is guided by collaborative project delivery practices and associated challenges discussed next.

1.1 Background

Construction is often considered a gritty, hard-nosed, hard-hat industry. The industry, despite its image, accounts for approximately four percent (4.3%) of the United States (U.S.) gross domestic product (GDP) or $826.1 billion dollars in expected added value in 2018 (Bureau of Economic Analysis (BEA), 2018). It encompasses a host of design and construction professionals such as architects, engineers, steelworkers, electricians, and plumbers, to name a few. These disciplines come together working towards one common goal, to deliver construction projects for their clients safely, on time, and below budgeted costs.

As various organizations come together, they bring their vast knowledge base and expertise. Individuals from respective organizations are expected to deploy their knowledge to advance project objectives while controlling organizational and project risks. But, what happens when they fail to agree on certain aspects of the project such as the price of a completed change order resulting from added design scope? What about other project risks highlighted by the industry such as errors, omissions, cost overruns, and productivity losses? These are common dilemmas which occur on many construction projects and inherently imposes risks on the entire project team. Rahman and Kumaraswamy (2002) maintain risks must be dealt with whether by sharing, transferring, managing, accepting, or controlling for it.

Many problems in construction projects are exacerbated due to the lack of clear communication, coordination, and early collaboration. Consequently, companies rely on claims, arbitration and/or litigation to solve their problems. This well-known fact has been delineated by industry practitioners and researchers alike, changing the way owners and contractors deliver construction project while managing risks such as cost, schedule, and project uncertainties.

Traditional construction project delivery methods such as design-bid-build (DBB), construction management (CM), and design-build (DB) have dominated construction contracts in the U.S. for years. These trusted methods, though effective, do not always encourage collaboration and communication across organizations during the early planning stages of the construction process. In fact, many of these approaches put contractors in a position where behaviors are focused on transaction costs [i.e., transaction cost economics (TCE) or any activity engaged in to satisfy each party to an exchange values in accord with expectations that are both given and received (Ouchi, 1980)] and positioning themselves against uncertainty involved in project delivery (Li, Arditi, & Wang, 2013).

More recent relational project delivery methodologies (e.g., Project Partnering, Strategic or Project Alliancing, and Integrated Project Delivery [IPD]) surfaced in the late 1980s continuing over a fifteen year period bent on increasing levels of collaboration across organizations and to help mitigate risks (Lahdenperä, 2012). Relational governance theory explains this phenomenon as the "the enforcement of obligations, promises, and expectations occurring through social processes that promote while normalizing flexibility, solidarity, and information exchange (Poppo & Zenger, 2002)." In this arrangement, economic safeguards found in traditional contracts are relaxed as individuals focus on trust to minimize opportunistic behaviors (Zaheer & Venkatraman, 1995).

These newer collaborative contracting practices came into existence to meet the expectations of clients in delivering predictable results and satisfaction through integrated teams (Baiden, Price, & Dainty, 2003). An integrated team as defined by Baiden et al. (2003) is:

> "a team of individually distinct groups or teams with functional identities working together consciously and in a continuous way to achieve a set objective or target through a system of unrestricted cross-sharing of information. In turn, efficient and effective decision making occurs under competent team leadership with the ability to drive the overall optimum achievement of initial goals set for the team."

Within this definition, the motivation is to merge multi-disciplinary organizations into one cohesive unit singularly responsible to the client and is culturally joined together. However, removing cultural barriers requires strategies such as project team member consistency, colocation, and early involvement of all team members (e.g., prime contractors and specialty subcontractors) in decision-making (Baiden et al., 2003).

These team integration strategies help project team members share information openly and honestly while tapping into a broad range of knowledge and expertise early on when decisions are less costly and more effective (Ospina-Alvarado, Castro-Lacouture, & Roberts, 2016). These distinct advantages comprised of experiences, mental models [i.e., an organized structure of shared knowledge among the team (Mohammed, & Dumville, 2001)], and motivation brings about goal alignment within project teams (Dietrich, Eskerod, Dalcher, & Sandhawalia, 2010).

Recent research points out existing paradoxes in the field of AEC project management and collaborative approaches as being generalized ideas that, when followed, do not always improve performance (Jacobsson & Roth, 2014). In particular, partnering research urges us to place greater emphasis on informal attributes and formal mechanisms to add richness to its practice and implementation (Bresnen, 2007; Suprapto, Bakker, & Mooi, 2015). As an example, a Delphi study of industry professionals was used to establish an alliance team integration performance index using quantitative measures (Che Ibrahim, Costello, & Wilkinson, 2015). Their study provides a useful tool for AEC researchers and practitioners that monitor the strengths and weaknesses of team integration during project delivery. In another instance, Ospina-Alvarado et al. (2016) assembled a ranking of integration attributes based on a survey of AEC professionals to delineate what team integration means to a project. Both studies broadly address the need suggested by Baiden, Price, and Dainty (2006) to develop team integration measures, yet are sparse in illustrating the behavioral commitments and understandings required of individuals.

The literature lacks clear evidence demonstrating how collaborative practices (e.g., partnering workshops, partnering training sessions) enhance team integration and, more importantly, goal alignment and behavioral systems. Some argue, increasing collaborative practices alone does not improve team integration and performance outcomes (Cheng & Li, 2001; Kumaraswamy et al., 2005). However, these collaborative practices are still believed to help interorganizational AEC project teams align their goals and objectives for the benefit of the individual, team, and project performance (Dietrich et al., 2010).

Although the architecture, engineering, and construction (AEC) literature are widespread on the importance of team integration and cohesion, little emphasis is placed on the goal alignment aspect and its relationship to performance outcomes. This research aims to explore the relationship between goal alignment and performance outcomes in interorganizational AEC project teams, in the context of partnered-projects. Additionally, it examines the moderating effects of transactive memory systems (TMS) on this relationship. Understanding this is important to address a gap in the literature, therefore, several objectives are posited for this study. The objectives of this study are to (1) Develop a framework demonstrating the relationship between project risk factors, collaborative project delivery practices, goal alignment, TMS, and performance outcomes; (2) Test an evaluation metric for goal alignment and utility of TMS metric to investigate AEC collaboration during project delivery; (3) Help facilitate collaborative contracting in construction projects by identifying key characteristics individuals hold in common; and, (4) Provide theoretical contributions in AEC literature understanding collaborative project delivery methodologies as a form of relational governance.

To achieve the study objectives, surveys of industry professionals involved in collaborative project delivery is collected from six case studies. This permitted the researcher to investigate the effects of goal alignment, in the context of partnered projects, on individual, team and project performance. It is further anticipated that project team members' transactive memory system (i.e., knowledge processing system for coordination, communication, and specialization) acts as a moderator of performance outcomes. Process and performance feedback (i.e., monthly partnering meetings, partnering training sessions, professional neutral third-party facilitator, monthly scorecards, etc.) is given to project team members at defined intervals during project delivery and is inherent to partnering processes. This feedback intends to help project team members align their goals, resources, and efforts with those of the project. It also encourages team collaboration and trusting relationships to develop within and between project teams.

To summarize, this section described the challenges and continued efforts the AEC industry is pursuing to address team collaboration. Despite adversarial mentalities reported in traditional project delivery methods, collaborative project delivery methods and approaches such as IPD and partnering are closing in on key informal attributes and mechanisms. The literature, as evinced above, is still emerging in explaining how collaborative practices manifest within AEC project teams. Thus, the problem statement below articulates the rationale for this dissertation.

1.2 Problem Statement

AEC construction project teams increasingly seek to improve project performance efficiency (i.e., cost and schedule) and effectiveness (i.e., quality and safety) while also mitigating conflicts without clear guidance or direction (Suprapto et al., 2015). Many attribute this dilemma to the fragmentation among disciplines during project delivery processes (Fellows & Liu, 2012; Roehrich & Lewis, 2010). The benefits of collaborative working arrangements such as project partnering is typified as a vital component to help address this discontinuity in project teams

(Anderson & Polkinghorn, 2011; Black, Akintoye, & Fitzgerald, 2000; Bubshait, 2001; Gransberg, Dillon, Reynolds, & Boyd, 1999; Hong, Chan, Chan, & Yeung, 2012). Anderson and Polkinghorn (2011) report several key benefits of project partnering such as improved team collaboration, improved conflict resolution strategies to manage project risks and uncertainty, stronger relationships and increased trust among project teams. Few of these studies, until recently, have examined how team related factors are related to project performances in the context of AEC project teams (Comu, Iorio, Taylor, & Dossick, 2013; Franz, Leicht, Molenaar, & Messner, 2016). A gap exists in the AEC literature to advance this topic, in particular, the role goal alignment and TMS have in the project delivery process.

For AEC industry researchers and practitioners, it is important to advance project-based collaboration as a means to improve the certainty of project performance outcomes. Especially considering challenges from the temporary nature of construction projects and its ever-changing teams. In fact, Suprapto et al. (2015) suggest continuous attention must be applied by managers to enhance the benefits of collaborative practices (e.g., project partnering) on successful project delivery. This information is of great value to both owners and contractors in an industry often associated with trust and communication issues resulting in construction disputes and adversarial mentalities (Bresnen, 2007; Drexler Jr. & Larson, 2000; Ng, Rose, Mak, & Chen, 2002).

The challenge inherent in AEC projects is to gain willing cooperation among interorganizational project teams. These teams, while transient across projects, pick up habits and practices through experience that can have a positive or negative effect on performance. Not only are there project teams, but teams of teams at various levels that form over the life cycle of a project. For example, AEC projects are comprised of individual team members (i.e., individual members of each organization) and interorganizational sub-teams (i.e., owners' team, design and engineering team, contractor team, and subcontracting teams). Collaborative project delivery approaches attempt to bring these teams together early and often during project delivery. Reason being, one can expect optimized results and efficiencies through all phases of design, fabrication, and construction (AIA, 2007).

Despite noticeable benefits, some contend collaborative working arrangements are grounded within interpersonal dynamics and relationships which explain the effect on project performance (Bresnen, 2009; Bygballe, Jahre, & Swärd, 2010; Cacamis & El Asmar, 2014; Doloi, 2009; Yeung, Chan, & Chan, 2012). In other words, AEC projects are people-oriented practices which require varied organizations to coalesce around shared goals and objectives. Many of these may conflict with those of the individual or organization. Hence, several levels of analyses are present with disparate objectives for individuals versus interorganizational sub-teams working on an AEC project.

Research shows how behavioral commitments involve team cognitive processes (e.g., team mental models, transactive memory systems) and impacts process and project performance for team members involved in information system development projects (Hsu, Chang, Klein, & Jiang, 2011; J. S. Hsu, Liang, Wu, Klein, & Jiang, 2011). Hsu et al. (2011b) assert continuous team building activities increases team mental models and ultimately facilitates better problem solving, goal alignment, learning, and improves performance outcomes. However, literature is silent in terms of parsing out the role of collaborative "feedback" practices on goal alignment among individuals.

1.3 Research Goal and Objectives

The primary aims of this research are to investigate "*how goal alignment affects performance in AEC project teams when collaborative project delivery practices are followed*." An interesting phenomenon is present where teams of teams working on projects attempt to align individual goals with those of interorganizational sub-teams. A gap exists in the AEC literature, demonstrating a need to systematically identify the underlying attributes of collaborative project delivery approaches which result in better performance. Focusing on partnered-projects as a type and subset of collaborative AEC project delivery approaches, the specific objectives of this study are to:

1. Develop a framework demonstrating the relationship between project risk factors, collaborative project delivery practices, goal alignment, TMS, and performance outcomes by;
    a. Qualitatively examining the following at partnered-project level:
        i. The links among *project risk factors*, *collaborative project delivery practices*, and *project performance*; and,
    b. Quantitatively examining the following at individual-level in interorganizational AEC project teams:
        i. The relationship between *individual/team performance*, *goal alignment,* and *TMS*.

2. Test an evaluation metric for *goal alignment* and utility of *TMS* metric to investigate AEC collaboration during project delivery;

3. Help facilitate collaborative contracting in construction projects by identifying key characteristics individuals' and projects' have in common.

4. Provide theoretical contributions to AEC literature understanding collaborative project delivery methodologies as a form of relational governance.

Based on the goals and objectives of this research, a conceptual framework in Figure 1.1 is proffered illustrating the moderating role of team behaviors during project delivery. The framework is used as a guide for this study to investigate the relationships among *project risk factors*, *collaborative project delivery practices*, *goal alignment*, *TMS*, and *performance outcomes*. In addition, several metrics are tested which are made available to researchers in AEC literature for future research involving AEC project teams. Thus, these metrics which are generally found within organizational research are advanced to AEC literature.

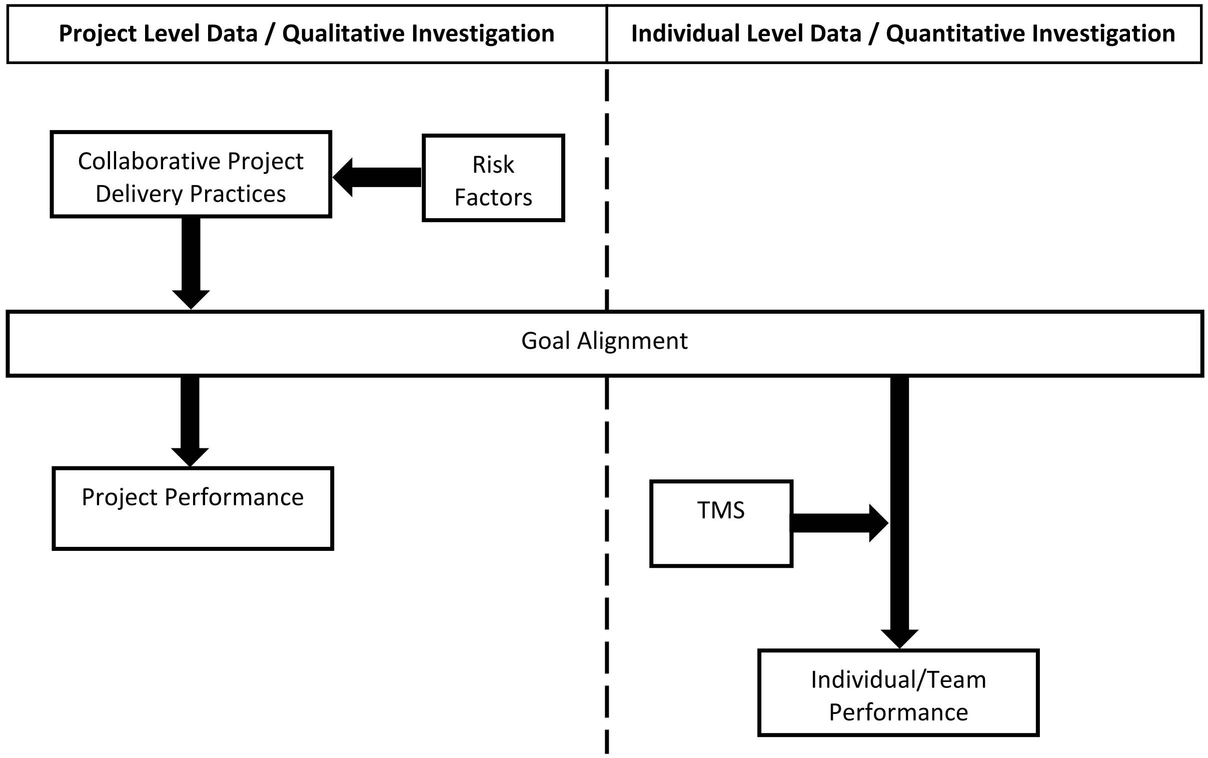


Figure 1-1: Framework illustrating the relationships between project risk factors, collaborative project delivery practices, goal alignment, TMS, and performance outcomes.

1.4 Research Scope

This study examines collaborative project delivery through the lens of partnered-projects. Partnering in the context of AEC industry is more commonly defined as "a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources" (Construction Industry Institute [CII], 1989). A purposeful pool of partnered-projects is used to collect both individual-level data from AEC project teams and project information representing a small subset of the AEC construction industry. The final study participant sample (n) size was 125 potential survey respondents from six case study projects.

This is achieved in collaboration with the International Partnering Institute (IPI) to identify ongoing or recently completed partnered-projects. By distinctively selecting the sample the researcher is able to find individuals who experience the phenomena, are representative of the ideal population, can be assessed through survey or observation on information related to the research question (Miller et al., 2011). Miller et al., (2011) further argue how important it is to understand the multilayered and temporal structure within the phenomena as it will guide the analyses approach.

Project risk factors such as size and complexity coupled with collaborative practice information are characteristics of each project. Some projects (e.g., partnered-projects) employ collaborative practices during project delivery such as creating partnering charters, partnering workshops, and using partnering scorecards and performance surveys to objectively measure how well teams are performing on pre-determined goals and objectives. These project characteristics, though limited by the number of case study projects, will offer both quantitative and qualitative information to enhance the intended data analysis for this study. The project team level, as a unit of analysis, becomes useful as project-specific information is integrated into analyses and used to triangulate data across multiple case studies (Campbell & Fiske, 1959).

Collaborative working occurs during many project delivery approaches and encourages team integration. Collaborative project delivery practices such as project partnering seek to increase team integration and owner value while reducing waste and inefficiencies during project delivery (Lahdenperä, 2012; Pishdad-Bozorgi & Beliveau, 2016). The underlying motivation behind collaborative project delivery arrangements is to spread risks and rewards evenly among project stakeholders (i.e., owner, design, and contractor). This inherently influences individual, sub-team, and project performance outcomes due to behavioral norms enabled through formal and informal contract agreements.

Informal relational contracting strategies as those mentioned above build solidarity, flexibility, and trust within AEC project teams. Thus, partnered-projects are well-suited to represent collaborative project delivery methodologies because they can respond to both teams of teams and relational governance theory. Teams of teams are widespread in AEC projects, yet are not systematically investigated in AEC literature.

1.5 Research Questions

The overall research question in this study is to understand "*how goal alignment affects performance in AEC project teams when collaborative project delivery practices are followed*." Two levels of analyses are relevant to this research question, project/team level, and individual-level (see Figure 1-1 above). The specific questions intended to address each level of analysis are given below:

Project Level Questions

- What *collaborative project delivery practices* impact project *goal alignment* in partnered-projects?
- Do *project risk factors* impact *collaborative project delivery practices* and, thus, *goal alignment*?

- What are the relationships between *project risk factors*, *collaborative project delivery practices*, and *goal alignment* in partnered-projects?
- Does *goal alignment* affect *project performance*?

Individual-level Questions

- Does individual *goal alignment* affect *individual performance* perceptions? If so, is this relationship moderated by individual *TMS*?

1.6 Research Design and Approach

The research design is central to any research study and requires many thought trials. This provides not only the plan but the structure required to effectively answer research questions and control variance (Kerlinger & Lee, 1999). The goals of this study are obtained by investigating the variance across AEC project teams using multiple case study evidence from six projects. This study utilizes a mixed-methods research approach to collect, analyze, and draw inferences among project and individual-level data.

The research documents and study data collection instruments were presented to the Institutional Review Board (IRB) at Michigan State University for approval. The documents included the survey instruments, structured interview questions, and other protocols required for human subject research. This study received an expedited approval due to its voluntary nature and maintains subjects' anonymity when clear identifiers are requested from study participants.

To achieve the main objectives of this research, a mixed-method approach is followed. A mixed-method approach facilitates exploratory research using two or more types of data collection and data analysis methods (i.e., qualitative, quantitative). These data are used to integrate findings and draw inferences from a single study or theoretical perspective (Miller et al., 2011). The two types of data, per Miller et al. (2011), enhances data collected sequentially and provides a complete understanding of the phenomenon. Thus, multiple research questions and hypotheses are asserted as in sections 1.5 - 1.7 above. There are three stages followed in this study.

Project-specific data such as collaborative project delivery practices (e.g., use of partnering charters, scorecards, workshops) and project team rosters are collected from main project participants (e.g., partnering facilitator, owner representative, or Construction Manager/General Contractor (CM/GC) project manager). Structured interviews are performed to collect data from key stakeholders representing the owner team (e.g., owner, owner representative, or other key stakeholder involved in project delivery) regarding project performance outcomes (e.g., cost, schedule, quality, and conflict resolution).

Using project rosters, quantitative data is gathered from surveys administered to project team members. Data collected from surveys are used to measure individuals' perceptions of goal alignment, TMS, and performance outcomes. The survey is used to collect data at or near project completion. It is anticipated perceptions will change during the life cycle of a project, thus vary across individuals. Therefore, surveys are initiated at or near project completion to capture a recent picture of individuals' perceptions relating to variables in this study.

During stage one, a partnered project delivery framework (A. E. Sparkling, Mollaoglu, & Kirca, 2016) is initiated via case study evidence to verify its applicability to project level data analysis (Sohani, 2016). From this initial investigation, the framework is refined and used to develop a comprehensive survey incorporating literature review and industry feedback. At stage two, the researcher collects data from the identified partnered-projects and subsequent project teams using surveys, structured interviews, and email correspondence. Last, data analysis is completed among both qualitative and quantitative data. The researcher uses pattern-matching and content analysis as a means to provide a cross-case synthesis. Concurrently, quantitative data are analyzed using confirmatory factor analysis and multiple regression/correlation analysis (MRC). Chapter 3 gives a detailed description of the stages and mixed-method approach followed in this study while the expected deliverables are covered next.

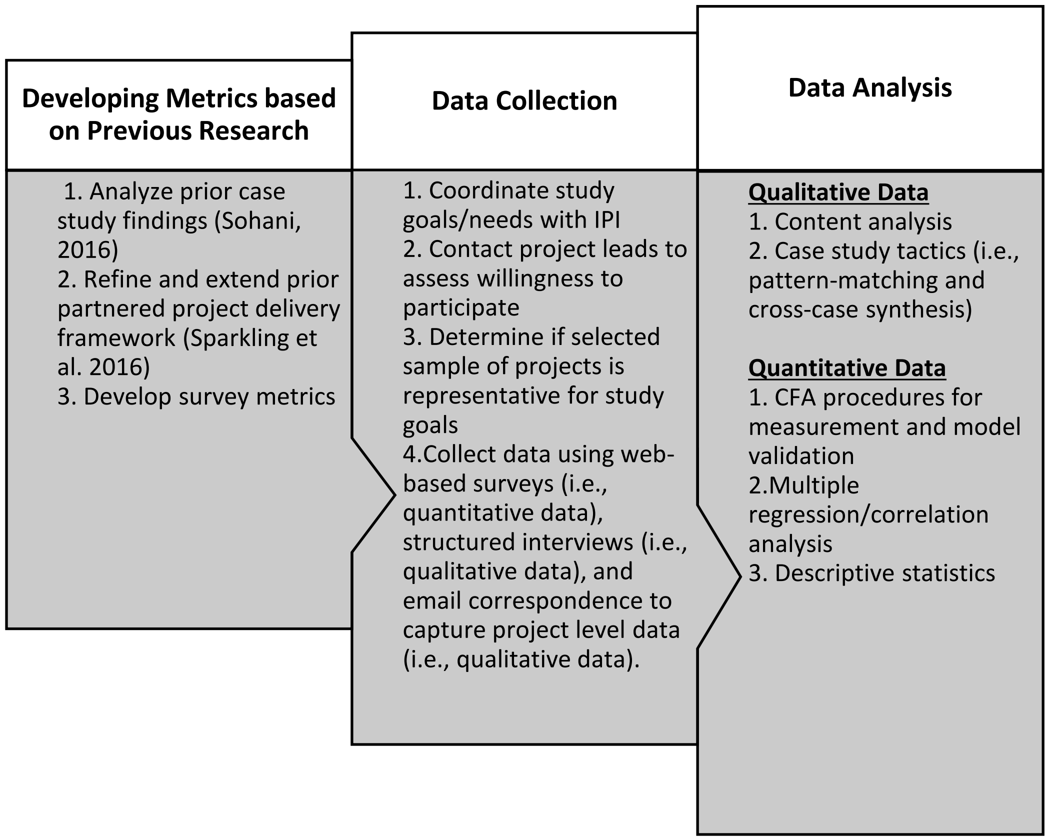


Figure 1-2: Three primary stages followed in this study as part of the research approach.

1.7 Expected Deliverables

The expected theoretical and practical contributions to the body of knowledge as a result of this research are:

(1) A framework demonstrating the relationship between project risk factors, collaborative project delivery practices, goal alignment, TMS, and performance outcomes;

(2) Test an evaluation metric for goal alignment and utility of TMS metric to investigate AEC collaboration during project delivery;

(3) Best practice guidance on collaborative contracting practices and associated behavioral attributes which underlie effective implementation; and,

(4) Future guidance on key project team metrics to explore processes integral to better performance outcomes in collaborative project delivery methodologies.

1.8 Dissertation Organization

This dissertation is structured around seven chapters. Chapter 1 provided an introduction to relevant literature underpinning this research and included the problem statement, research goals and objectives, research scope, research questions, stated hypotheses and propositions, research design and approach, and expected deliverables. Chapter 2 provides an in-depth review of the literature for this research focusing on relational governance, team theory, goal alignment, and underlying characteristics of project partnering. The methodology is presented in Chapter 3 which includes constructs, metrics, and survey development. Detailed results are reported in Chapter 4 stemming from cross-case synthesis procedures. Chapter 5 explicates the results of data and model validation while Chapter 6 presents findings and discussion from both multivariate regression analyses and cross-case synthesis. Chapter 7 concludes this research by summarizing the findings, conclusions, limitations, theoretical contributions and directions for future research.

CHAPTER 2 LITERATURE REVIEW

The chapter begins by introducing the current state of the literature related to collaborative working arrangements in construction projects. More importantly, why the issue of team integration and its implications to project performance continues to remain unclear. This is followed by an introduction to project partnering, contractual, and procurement practices which challenge project teams. These theories are beneficial in unlocking misguided assumptions often attributed to newer construction practices and their benefits to increased performance. Next, the literature shifts to provide an in-depth exploration into the well-defined team and relational governance theories generally found in organizational research directing attention to AEC collaborative working implications.

2.1 Background

The AEC industry is increasingly challenged with improving the efficacy of project team performance through collaborative working arrangements (Suprapto et al., 2015). Collaborative working arrangements synonymous with relational contracting methods such as alliancing, joint ventures, and project partnering are all comprised of interorganizational project teams (Rahman & Kumaraswamy, 2005; Suprapto et al., 2015). Recent research shows that cohesive teams are perpetuated by strategies to facilitate team integration (Franz, Leicht, Molenaar, & Messner, 2010; Franz & Leicht, 2016). Efficient knowledge sharing and processing systems also called transactive memory systems (TMS), are integral to cohesive project teams and their tasks coordination (Comu et al., 2013).

A strong TMS allows two or more people to cooperatively and efficiently encode, store, retrieve, and communicate information from different subject experts (Hollingshead, 1998b; Kyle Lewis, 2003). A TMS exists within interorganizational project teams and can guide the success of the project.

In the AEC industry, project teams are generally responsible for the success of a project although from different perspectives. These teams must work to align competing goals between their respective organizations versus those related to the project. An opportunity exists within collaborative projects which challenge this interesting dichotomy by way of feedback systems. According to Manley and Chen (2015), project governance mechanisms whether formally (e.g., open book cost accounting or shared risks structures) or informally (e.g., integrated team selections or relationship workshops) instituted in contracts provides feedback enhancing project outcomes. From this, learning routines are developed among project teams. It is within these learning routines where individuals and organizations gain feedback which increases their collaborative project understanding (Manley & Chen, 2015). This feedback information is brought forward into future projects and is related to positive performance outcomes.

The idea of dynamic learning feedback system in AEC literature is presented in the collaborative model asserted by Manley and Chen (2105). Figure 2-1 shows their conceptual model for a dynamic learning system among multiple stakeholders and across organizational levels during project delivery. In the model, collaborative relationships established during a project life cycle are at the center of the feedback loop. According to Manley and Chen (2015), a three-stage sequential learning process exists and is comprised of exploratory, transformative, and exploitative learning. Exploratory learning occurs during routines of such as workshops where team members freely communicate and share knowledge to achieve mutual goals and objectives.

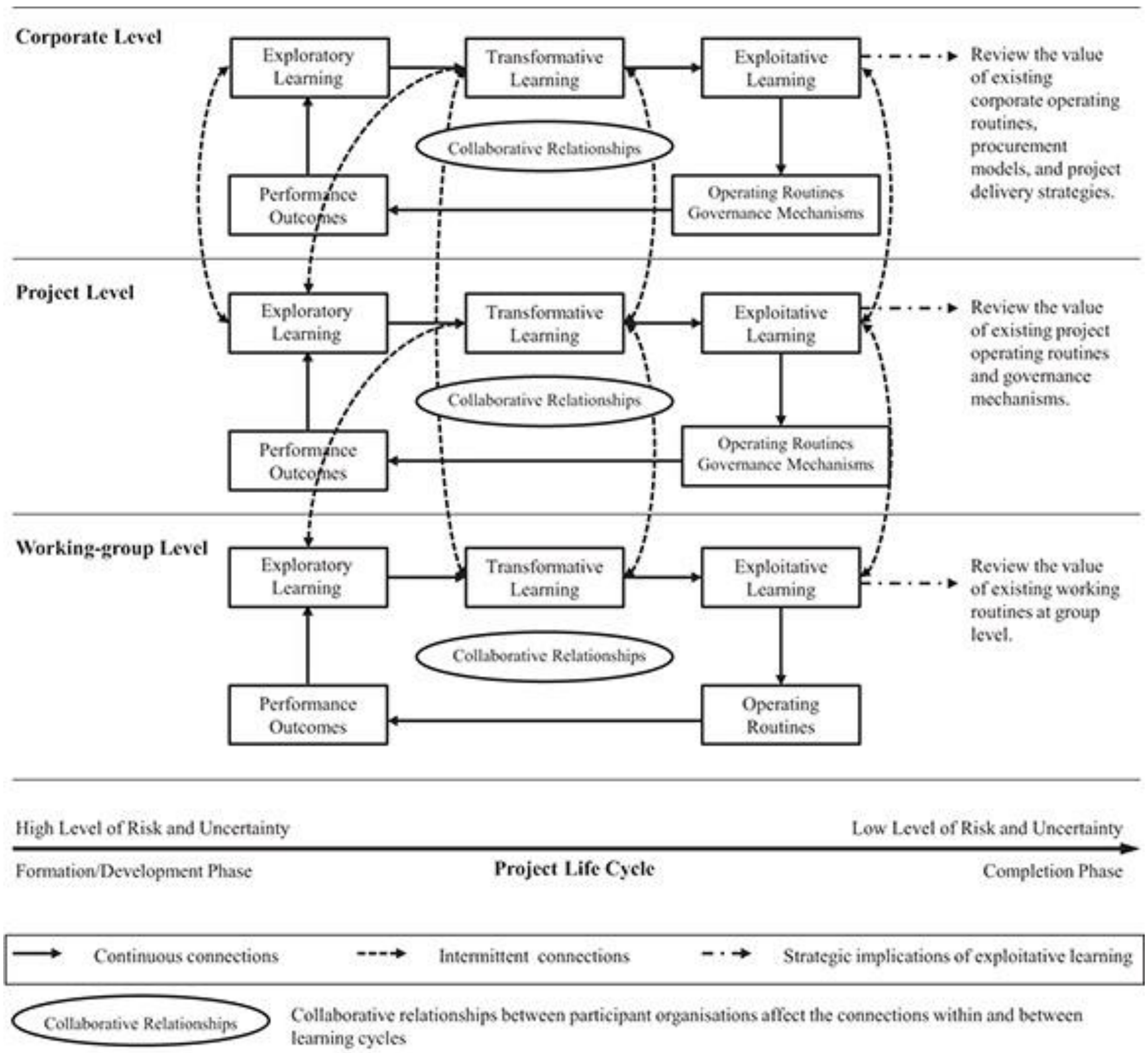


Figure 2-1: Collaborative model: dynamic learning capability amongst multiple stakeholders across organizational levels over the project life cycle, with performance feedback (Manley & Chen, 2015).

Transformative learning is the process whereby individuals exchange, disseminate, and codify knowledge for future use during interpersonal interactions. Knowledge gained from collaborative project experience through exploratory and transformative learning is made available or matched to future conditions. This is referred to as exploitative learning. In the meantime, collaborative relationships create learning environments where individuals' experience is increased. As a result, the operating and governance mechanisms lead to empowered decision-making behaviors among project teams (Tuuli & Rowlinson, 2009).

Group learning and feedback encourages team members to commit resources towards multiple goals and objectives (DeShon, Kozlowski, Schmidt, Milner, & Wiechmann, 2004). This is important within construction projects due to the interdependencies of organizations in project delivery. Broadly, there is an ongoing effort to efficiently manage resources always seeking to reach an optimal point. However, the effects of feedback are generally not investigated. This feedback system helps the team develop a systematic way to realign efforts and resources to the project when deviations from goals are detected. In doing so, a system emerges that allows the team to manage knowledge and information related to the project and can be essential to performance outcomes.

The performance of misaligned teams has been connected to the type of feedback instigated (e.g., diagnostic information and process related) and can vary based on the makeup of the team (Johnson, Hollenbeck, Scott DeRue, Barnes, & Jundt, 2013). For example, interorganizational teams operating under a project partnering arrangement (e.g., construction project teams) will respond to feedback differently than an intraorganizational self-managed team (e.g., product development team). It is, therefore, anticipated that transactive memory systems vary across organizations and impact performance outcomes especially when feedback is present. This shared knowledge system enables interorganizational project teams to efficiently coordinate tasks and information processing during project delivery. What motivates and limits the effectiveness of many organizations working in teams are transaction costs in project delivery (Li et al., 2013) and building a truly integrated team (Franz et al., 2016). Ultimately, project risks and uncertainties are minimized with increased team cohesion, integration, and a well-developed TMS.

2.2 Project Partnering

Partnering in the context of AEC industry is more commonly defined as "a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources" (Construction Industry Institute [CII], 1989). Construction partnering is a network of self-organizing project teams which includes feedback systems that help to align project objectives with shared business goals and expectations (Bennett & Peace, 2007; Construction Industry Institute [CII], 1989). These interorganizational project teams are typically represented as owners, designers, and contractors.

Briefly, project partnering was developed in the 1980s by the U.S. Army Corps of Engineers as a way to mitigate construction disputes using joint workshops between owners and contractors (CII, 1989). It started as a voluntary arrangement between these two parties and has since evolved into a practice that is followed formally in contracts (Lahdenperä, 2012). The approach commonly uses a partnering charter to establish agreed upon goals and objectives for the project and its participants. A partnering champion or facilitator is used to help lead the process during workshops and partnering meeting. The primary motivation is to ensure project objectives are the focal point for the team. It is also important to communicate a succinct decision-making process to resolve issues or disputes. Project partnering is also underutilized in the construction industry, while longstanding and classified as a best practice (Construction Industry Institute [CII], 1996, Lahdenpera, 2012).

Partnering literature broadly covers partnering from the perspective of success attributes (Black et al., 2000), performance outcomes or benefits (Gransberg et al., 1999), and emergent collaborative working environments (Jacobsson & Roth, 2014). Various approaches are offered in the literature to implement partnering based on both informal aspects (e.g., philosophically focusing on trust, good-will, commitment) and formal tools (e.g., procedures and processes such as workshops, scorecards, etc.) (Crespin-Mazet, Havenvid, & Linne, 2015). Partnering implementation is best achieved when properly aligned with project risk factors (Eriksson, 2010).

2.2.1 Project Risk Factors

Crespin-Mazet, Havenvid, and Linne (2015), in their case study, found relational congruence between the project team as integral in decisions to pursue partnering. This supplants traditional notions which assert complexity, uncertainty, and risks as the most prominent factors informing this decision (Eriksson, 2010). What this suggests is the need to facilitate longer-term relationships, shifting from project partnering to strategic partnering. Relationships become more solidified by trust, commitment, and commonality of goals due to increased interactions instigated during project partnering (Crespin-Mazet et al., 2015). An underlying question is whether these gains are achievable by managing the behavioral attributes on a single partnered project.

The success of project partnering is typified within industry reporting (International Partnering Institute [IPI], 2017), yet has not been fully researched in a manner that permits robust evidence. These risk factors are also critical when building collaborative project teams during the procurement process (Rahman & Kumaraswamy, 2005). For example, project partnering is well-suited for routine projects lacking size and complexity and, therefore, are identified as low in risk (Gransberg & Scheepbouwer, 2015). Risk factors will also interact with collaborative practices which positively impacts the relational behaviors of the project team (Suprapto et al., 2015). Thus, it is important to adequately access this risk and ensure the level of partnering practices are fitting for the project (Eriksson, 2010). Based on this discussion, the following proposition is given:

Proposition 1: *Project risk factors and the level of collaborative project delivery practices in partnered-projects are positively related;*

According to the IPI (2017b), partnering should be implemented based on certain perceived risk factors such as project value, complexity, political significance, and the experience of the team. Risk related factors can be disaggregated into contractual and project risk which occur across the various phases of construction project delivery. According to McKim (2005), project risks are often underestimated by construction professionals while contract related risks are ignored altogether. This study takes into account the external types of risk using the matrix in Figure 2-2 which are then codified into partnering agreements and charters. The figure illustrates how various risks levels are determined, identifies risk factors, establishes the desired level of engagement, reports expected benefits and costs to implement, and recommended partnering elements for success.

When followed, the criteria guide the level of partnering implemented for a project. These levels range from one to five with one being low risk and five the highest amount of risk. The project risk factors are scored based on the following:

1. Project value or cost
    a. Micro/Short duration ($0 - $5M)
    b. Small ($5M - $10M)
    c. Medium ($10M - $25M)
    d. Large ($25M - $250M)
    e. Very Large/Mega ($250M - $500M)

2. The degree of complexity (e.g., short timelines, schedule constraints, uncommon materials or designs)
    a. Standard complexity
    b. Moderated complexity
    c. Increased complexity
    d. High complexity
    e. Highly technical/complex design and construction

IPI Vertical Construction Project Partnering Scalability Matrix

Scale your Partnering:
In order to determine the level of Partnering that you should apply to your construction project, take a moment to collaboratively assess your project risk factors.
The higher the risk, the more intensive your Partnering efforts should be. When in doubt, scale your Partnering efforts upward to set your project up for success; you can always scale it back down once the project is underway.

	Risk Factors*					Partnering Structure and Elements	Benefits and Approx. Cost**
Level	Project Value	Complexity	Political Significance	Relationships	Desired Level of Engagement		
5	**Very Large/Mega** (airport terminal, hospital, power plants, etc.) **($250M-$500M+)**	Highly Technical and Complex Design and Construction	High Visibility/oversight Significant strategic project	New Project Relationships including: new contractors, sub, agencies, third-parties, high turnover rate of subs or other high potential for conflict (strained relationship, previous litigation, or high probability of claims)	Very High	Professional neutral facilitator Partnering training required for all team members Project charter Multi-tiered Partnering (executive- core team - stakeholder) Monthly Partnering meetings (design through construction) Special task Forces for specific issue resolution Stakeholder on-boarding/off-boarding Subcontractor on-boarding/ off-boarding Monthly surveys Executive sponsorship Field-level decision making Issue resolution ladder and DRB Facilitated dispute resolution	Very high accountability, Issues tracked and decisions made timely, Momentum maintained as progress continues in spite of issues that arise Approx. $20,000/qtr.
4	**Large** (new design, new contracting method, challenging rehabilitation/renovation) **($25M-$250M)**	High Complexity (short timeline/schedule constraints, uncommon materials, new supply chain, etc.)	Probable - Organizational image at stake	New Contractors or CM, New subs/relationships	High	Professional neutral facilitator Partnering training required for all team members Project charter Multi-tiered Partnering (executive- core team - stakeholder) Quarterly Partnering meetings (design through construction) Stakeholder on-boarding/off-boarding Subcontractor on-boarding/ off-boarding Monthly surveys Executive sponsorship Field-level decision making Issue resolution ladder and DRB Facilitated dispute resolution	More timely decision-making in field, Stakeholders phased in and out, Designers involved throughout process Approx. $10,000-$15,000/qtr.
3	**Medium ($10M - $25M)**	Increased Complexity	Likely, depending on the size of the client and place of importance	Established relationships New CM, subs, agencies, or other key stakeholders	Moderate/High (seeking risk mitigation and project efficiencies)	Professional neutral facilitator Partnering Training recommended Quarterly partnering meetings Project charter Monthly scorecards Executive and core team Partnering Executive sponsorship Field-level decision making Inclusion of stakeholders Issue resolution ladder and DRB Facilitated dispute resolution	Increased predictability, Reduced (zero) claims, Improved safety, Improved schedule, On or under budget Approx. $5,000 - $10,000/qtr.
2	**Small ($5M - $10M)**	Moderate Complexity	Unlikely, unless in a place of importance	Established relationships New subs New Agencies New Stakeholders	Moderate (seeking risk mitigation and project efficiencies)	Professional neutral facilitator <u>for kick-off</u> (minimum) Project charter 2 Project surveys (minimum) Executive sponsorship Field-level decision making Inclusion of stakeholders Issue resolution ladder and DRB Facilitated dispute resolution	Increased predictability, Reduced (zero) claims, Improved Safety, Improved Schedule, On or under budget Approx. $5,000 - $10,000/qtr.
1	**Micro/ Short Duration ($0-$5M)**	Standard Complexity	Unlikely, unless in a place of importance	Established relationships New subs New agencies New stakeholders	Low to Moderate for small budget and/or short timeline projects, Partnering can reduce risk and focus on project efficiencies	Professional neutral facilitator optional Project charter Executive sponsorship Field-level decision making Inclusion of stakeholders Issue resolution ladder and DRA/DRB Facilitated dispute resolution	Increased predictability, Reduced (zero) claims, Improved safety, Improved schedule, On or under budget Approx. $1,000/qtr.

Figure 2-2: IPI Vertical Construction Project Partnering Scalability matrix for collaborative partnering.

3. Political significance (e.g., place of importance, client size, organizational images at stake, strategic project)
    a. Unlikely
    b. Likely
    c. Probable
    d. High visibility/oversight
4. The degree of relationships (i.e., previous working experiences with other stakeholders, contractors, subcontractors, agencies, construction manager, etc.)
    a. Established relationships
    b. Newly formed relationships
    c. New project relationships or High potential for conflict based on past experiences

Risk evaluations using the criteria above becomes critical to assist project teams, not only in their decision to partner but to what extent. In fact, Gransberg et al. (1999) specifically point out that projects larger than $5M are ideal to incorporate formalized partnering practices. This is due to increased project complexities and a need to align team member behaviors' and goals' with those of the project as opposed to individual motives. The advantages of partnering are generally proffered by examining these partnering characteristics.

2.2.2 Collaborative Practices in Partnering

Project partnering, as defined in this study, is the process by which partnering processes and tools are incorporated either formally or informally into project delivery. Many partnering characteristics are shown as beneficial to drive the success of projects by way of aligning project teams. Process feedback can be general or specific, which is typically found in project partnering strategies. For instance, a survey of 264 construction professionals suggests top management commitment and belief in an integrated process is a highly important characteristic of partnering (Ospina-Alvarado et al., 2016). Meanwhile, they found training to be of medium importance and rated facilitators as neutral. Despite this, many of the partnering characteristics found in the literature are shown to drive the success of team and project performance.

Another example is that successful partnering can be attributed to the use of facilitators (E. W. L. Cheng & Li, 2002). When formalized in partnering contracts, the role of a professional neutral facilitator is to guide partnering workshops and meetings, lead efforts to collect partnering scorecards and communicate feedback from various metrics. The facilitator is also responsible for promoting cooperation between parties while remaining neutral on project specific content. They can also guide the team in formulating their partnering charter. A partnering charter codifies the mission statement, goals and objectives, and guiding principles for the project (Larson, 1997). Ultimately, a facilitator keeps the project team focused on achieving their defined partnering goals and objectives.

Project goals are generally broad and encompass ideas such as maintaining a safe project, meeting customer satisfaction, minimizing rework with a commitment to quality, and delivering the project on-time and under budgeted costs. Project goals are solidified through mission and value statements within project charters. This continuously reminds project teams of the holistic commitments to which they have agreed upon. In contrast, project objectives should be measurable, attainable, results-oriented, and time-bound. Project objectives may include metrics on cost and schedule growth, claims and disputes, or number of change orders related to errors and omissions associated with the design or construction (Gransberg et al., 1999). According to Earley (1990), goals influence performance outcomes and stimulate self-confidence, effort, and task strategies when feedback is present. In project partnering, feedback mechanisms such as goals provide feedback to align individuals' effort and attention towards common project objectives. The discussion above results in the second proposition:

Proposition 2: *Collaborative project delivery practices and individuals' goal alignment perceptions in partnered-projects are positively related*

Garnering the support and sponsorship of top management has also been identified as critical in partnering implementation (Cheng & Li, 2002). This assuages project team member concerns that manpower, resources, finances, and adequate time have been allocated towards partnering processes from the home office. Senior managers engaged in the partnering process have an opportunity to help identify and assess project risks, create proactive plans to manage and control risks, and establish decision-making processes to deal with them as they arise. Moreover, top management should empower all field level team members to make decisions in the interest of the project when problem-solving is required (Ng et al., 2002). These feedback processes send motivational and directional cues to individuals encouraging them to adjust their efforts or come up with new performance strategies (Earley, 1990).

Other partnering tools and processes used during project delivery also encourage collaboration and point to success. Some of these are attracting high levels of involvement from all stakeholders of the project (i.e., owner, designer, contractor, subcontractors, and end-users) and the development of a dispute resolution ladder which includes a facilitator when appropriate. The objective of a dispute or issue resolution ladder is to resolve issues quickly and at the lowest level possible rather than letting problems escalate. When they do escalate, the likelihood of cost and schedule impacts are increased.

Achieving full engagement from stakeholders helps to continuous realign the vision and goals of the project with those of the project team. Additional elements of partnering such as project scorecards for benchmarking project goals, holding partnering meetings, workshops to establish relationships and build trust, and training sessions to increase one's understanding of partnering concepts offer feedback clues to the project team (Eriksson, 2010; Ng et al., 2002). Performance feedback made available through scorecards can help individuals identify the need to adjust actions, however, does not always provide strategies to make adjustments. Thus, the role of professional facilitators becomes even more important. According to Cheng and Li (2002), partnering processes are reactivated when stakeholders are fully vested in its benefits and trust others intentions with its use. A summarized list of partnering practices is given below:

- Kick-off partnering workshop used to develop the partnering charter;
- Partnering charter that outlines:
    - Mutual goals and objectives;
    - Partnering maintenance and close-out process, partnering sessions and attendees, the frequency of meetings; and,
    - A clear dispute resolution plan mutually agreed upon by partnering participants;
- Partnering specifications;

- Engagement of a professional neutral third-party partnering facilitator;
- Partnering training;
- Executive sponsorship demonstrating top management commitment and support for the partnering process;
- Early involvement of key stakeholders in the decision-making process;
- Multi-tiered partnering (i.e., executive, project team, stakeholders);
- Subcontractor on-boarding/off-boarding where relevant parties participate in partnering sessions;
- Focused Action Strategic Teams (FAST) empowered for field-level decision-making as a means of timely issue resolution
- Monthly scorecards for continuous feedback on project team performance; and,
- Dispute resolution ladders.

All of these feedback processes and practices are closely related to other characteristics found during project delivery as reported by Sparkling, Mollaoglu, and Kirca, (2016) in their research synthesis of partnering literature.

2.3 Partnered Project Delivery Framework

Research points out the broad characteristics of AEC partnering literature and potential links among these characteristics (Mollaoglu et al., 2015; Sparkling et al., 2016). In their syntheses, 72 partnering studies are classified into several prominent categories using a meta-analytic review process. The work posits a clear taxonomy regarding partnering characteristics, specifically categorizing them *as drivers during partnered project delivery, project team characteristics*, and *performance outcomes* among others. Using the framework in Figure 2-3, a path to improved performance outcomes is proposed.

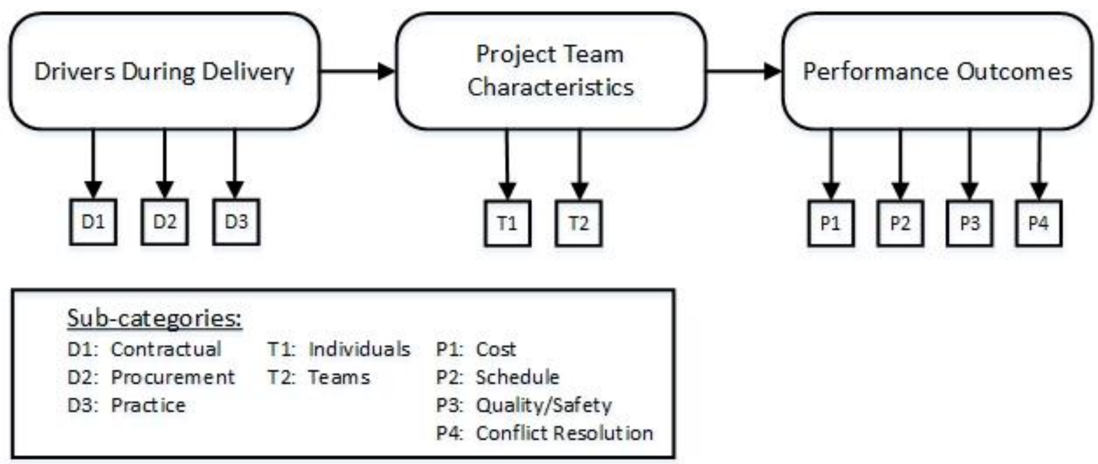


Figure 2-3: Partnered project delivery framework adopted from Sparkling et al. 2016

The path follows the three categories defined as 1) *Drivers during partnered project delivery* – best practices followed during contractual, procurement, and partnering practice related activities; 2) *Project team characteristics* – qualities possessed by individuals' and project teams' which may influence performance outcomes; and, 3) *Performance outcomes* – Improved project and organizational performance attributed to partnering implementation. Project performance benefits include improved cost, schedule, and quality/safety performance, along with strategies to manage conflict. Organizational performance related outcomes are those attributes such as creating and maintaining lasting relationships with partnering teams or working to improve organizational reputation in the industry. Other *performance outcomes* are those of individuals' and project teams'. Individual performance outcomes are those internal attitudes and beliefs held by individuals while team performance is concerned with developing team cohesion and trust.

Sohani (2016) implemented this framework via case study and found that partnered projects followed many of the *drivers* asserted as practices. In this analysis, partnering practices were connected to increased performance outcomes teams experienced during project delivery. This framework is further supported by a research synthesis of AEC partnering literature (Sparkling et al., 2016). Based on their analysis, the top elements of the framework categories as seen in the literature are reported. Using the results of cumulative research or meta-analytic techniques in AEC research is indirectly validated as a consequence of this study (Sparkling et al., 2016).

Sparkling et al. (2016) used meta-analytic procedures to their advantage by reviewing AEC partnering literature over several decades to spot trends, gaps, and direction for future research. For instance, in their synthesis, they not only provide a taxonomy of the literature but offer clues to connect the research streams. One particular stream has dominated the literature focusing on *drivers during partnered project delivery* (i.e., practices, contractual, and procurement) and the impact on partnering success. The literature points out many critical feedback attributes which are implemented in practice such as partnering workshops, project scorecards, clearly defined goals and objectives, etc. (Chan et al., 2004; Deborah Hughes, Williams, & Ren, 2012). The top practice elements as a result of their synthesis are shown in Table 2-1. Despite the importance of formal tools, contractual and procurement related elements as purported by Sparkling et al. (2016) are also useful to the effectuate project team performance.

Table 2-1: Analysis of Partnered-Project Delivery Framework Category: Drivers during delivery (Sparkling et al., 2016)

Top Drivers During Delivery	Number of times elements investigated in literature	Total number of studies investigating each subcategory (% of Total # of studies or 73)
Practice Elements (D1)		51 (70%)
Implementing partnering workshops for project teams	22	
Properly communicating mutual goals and objectives	14	
Benchmarking and monitoring partnering process (e.g., Project surveys)	12	
Establishing clear and compatible goals for project teams	11	
Using team building sessions across organizations	11	
Enabling free flow of information across organizational boundaries	10	
Engaging a neutral/third-party partnering facilitator to guide the process	9	
Using integrated technology systems that encourage collaboration	7	
Establishing well-defined roles and lines of responsibility	5	
Implementing an effective problem-solving process	5	
Contractual Elements (D2)		40 (55%)
The use of incentives/fees /risk-reward/ or gainshare-painshare agreements	14	
Explicit contracting language and/or form of contract	12	
Conflict identification and resolution strategy established in contracts	9	
Shared equity arrangements indicated in contracts	7	
Using a partnering agreement	6	
Equal power/empowerment afforded to all project teams	6	
Procurement Elements (D3)		25 (34%)
Early involvement of key participants (e.g., designer / contractor / subcontractors)	13	
Selection of parties with partnering experience	8	
Considering previous work experience with other members	6	
Selection of parties with technical expertise	6	

This study asserts an emerging framework underlies the frequently reported and researched practice elements. It is anticipated that practice elements can be further isolated.

For example, forming joint project charters and including mutual goals and objectives help project teams in goal alignment. Meanwhile, the structure is brought in goal alignment by way of clear dispute resolution/ problem-solving processes are followed, field level decision-making is encouraged, and professional facilitators are used to guide project teams. Feedback mechanisms such as partnering training/team-building sessions, partnering workshops, and scorecards are used as follow up processes to reinforce goal alignment. This study demonstrates that project risk factors and collaborative project delivery practices (i.e., partnering drivers or characteristics) influence goal alignment in AEC project teams.

Case study evidence supports the original partnered-project delivery framework and further exclaims the importance of both contractual and procurement drivers, in addition to practices (Sohani, 2016). The case study examined partnered-project data consisting of meeting minutes and project scorecards for an airport project with high-risk factors. Multiple feedback processes were incorporated into the project, some were using a neutral third-party facilitator, holding monthly partnering sessions, colocation of project teams, and formation of an issue resolution ladder. According to the partnered-project framework, these are all considered *drivers during project* delivery and offer feedback to the project team. Based on the analysis, the level of feedback was positively related to the performance of the project team and, subsequently, project performance. In particular, early involvement of contractor and subcontractors (i.e., procurement element) in the design process was shown to be positively related to team attributes such as establishing mutual trust and encouraging team commitment. Thus, our limited understanding of how softer metrics can be used to monitor project performance is emerging yet requires additional validation and testing from an alternative perspective and leads to the third proposition.

Proposition 3: *Individuals' goal alignment perception and project performance in partnered-projects are positively related*

Sparkling et al. (2016) purport several other useful elements that are beneficial to understand how team characteristics and performance outcomes are investigated in AEC literature. Table 2-2 illustrates the top project team level performance elements. Performance outcomes are shown in Table 2-3.

Table 2-2: Analysis of Partnered-Project Delivery Framework Category: Team Characteristics (Sparkling et al., 2016)

Top Project Team Characteristics	Number of times elements investigated in literature	Total number of studies investigating each subcategory (% of Total # of studies or 73)
Project Team Level Elements (T1)		40 (57%)
Establishing mutual trust within project teams	24	
Staying committed to the project teams goals and objectives	15	
Using integrated project teams	11	
Maintaining commitment to entire partnering process	7	
Committed to win/win attitudes	5	
Developing mutual interests among the project team members	5	
Individual-level Elements (T2)		11 (15%)
Individuals able to maintain positive attitudes	6	
Working with integrity during the process	2	
Maintaining enthusiasm in the partnering process	2	

Table 2-3: Analysis of Partnered-Project Delivery Framework Category: Project Performance Outcomes (Sparkling et al., 2016)

Top Project Performance Outcomes	Number of times elements investigated in literature	Total number of studies investigating each subcategory (% of Total # of studies or 73)
Cost Performance Elements (P1)		31 (42%)
Meeting costs targets for the project	10	
Improved cost savings during project delivery	7	
Reduced additional expenses due to changes and other concerns during project delivery	6	
Claims cost are reduced as a percent of the original cost	5	
Quality / Safety Performance Elements (P2)		27 (37%)
Improved the quality of the project	14	
Increased client and/or end-user satisfaction	8	
Improved safety performance for the project	8	
Reduced environmental issues and/or complaints	5	
Reduce wasted work or re-work	5	
Improved overall project design	5	
Schedule Performance Elements (P3)		29 (40%)
Projects are able to meet scheduling targets	12	
Reduced overall time in delivering the project	6	
Faster project delivery	6	
Conflict Resolution Elements (P4)		21 (29%)
Reduced disputes among project teams	10	
Improved resolution of claims and helps to avoid issue escalations	7	
Reduced litigation resulting from unresolved conflicts	7	

The above illustrates useful benefits offered from meta-analytic approaches and techniques, yet AEC literature is short on its implementation. A clear framework and taxonomy are developed using a research synthesis that provides a useful aggregation of theory. Meanwhile, a priori evidence alludes to its advantages and clearly implicates team attributes as crucial to understanding project partnering (A. E. Sparkling et al., 2016). Utilizing this as a guide, an emerging framework is developed for this study to understand collaborative project delivery approaches in the context of partnering.

2.4 Relational Governance, Teams, and Feedback

Team researchers continuously seek to explain and understand team effectiveness and performance. This is due to the fact teams are common components of organizational processes and performance outputs. Teams are regularly defined as “a distinguishable set of two or more people who interact, dynamically, interdependently, and adaptively toward a common and valued goal/objective/mission, who have each been assigned specific roles or functions to perform, and who have a limited life-span of membership” (Salas, Dickinson, Converse, & Tannenbaum, 1992). Teams and groups are often used interchangeably, thus follows in this study.

An introduction to relational governance theory is described in the next section followed by teams of teams and feedback theories.

2.4.1 Relational Governance

The notion of relational governance emerged from those seeking to understand the nuances of formal contracting and relational contracting (Carson, Madhok, & Wu, 2006; Poppo & Zenger, 2002). The seminal work of Williamson (1979) on transaction cost economics (TCE) gave rise to the phenomenon of opportunism and governance structures illustrating how opportunistic influences persist in formal contracts. However, relational contracting literature is critical of TCE as missing out on the social and relational embeddedness in the exchange (Granovetter, 1985). An emergent relational governance structure develops as organizations establish shared values and agreed-upon processes as part of interorganizational relationships (Zaheer & Venkatraman, 1995). Within this governance structure, trust is sought via social processes which encourage flexibility, solidarity, and information exchange (Poppo & Zenger, 2002).

Unforeseeable events are overcome in the social process by way of flexibility. According to Poppo and Zenger (2002), flexibility facilitates adaptation when untimely events happen during the exchange. Meanwhile, they assert solidarity is a means to create interorganizational problem-solving and commitments as organizations take actions and adjust behaviors. Behaviors such as mutuality and cooperation are further espoused through the use of information sharing regarding goals and objectives. These social processes embedded in relational exchanges safeguard against transaction hazards such as ambiguity, volatility, uncertainty, and opportunism. Moreover, the set-up costs are lower than formal contracts which are more complex and inherently signal distrust (Carson et al., 2006).

The principle component of relational governance is trust which is the extent to which fair negotiations are expected, commitments sustained, and belief that others parties will take action to fulfill future obligations (Claro, Hagelaar, & Omta, 2003). Trust plays a vital role in the economic exchange as a means to curtail asset specificity concerns. As interorganizational relationships develop and interactions reoccur over time, social elements and relational norms become more salient (Zaheer & Venkatraman, 1995). While interpersonal trust is important, interorganizational trust attenuates negotiated costs because agreements are reached sooner and parties are willing to reach a quick consensus (Zaheer, McEvily, & Perrone, 1998). In part, because interorganizational trust in conditions of relational governance structure and processes becomes institutionalized and does not solely rely on the boundary spanners [i.e., team members with external ties to access resources for the group (Katz, Lazer, Arrow, & Contractor, 2004)].

Collaborative project delivery methodologies, such as partnering, include both formal contracting and informal/relational contracting governance forms. This is further revealed by Lu et al. (2015) who assert contractual and relational governance are complementary attributes with positive effects on project performance. For example, traditional contracting terms are specified with equitable risk allocations and followed by parties working on partnered-projects while relational governance is effectuated when benchmarking metrics, partnering workshops, and conflict resolution strategies are not memorialized in the contract. This occurs specifically when working under informal partnering arrangements. Thus, a team mentality “clan or community” is formed seeking goal congruence toward explicit project goals and objectives established in partnering charters. This mentality generally reduces differences between individual and organizational goals (Ouchi, 1980).

Collaborative projects may rely on hybrid approaches drawing from both informal and formal mechanisms in negotiating the transactions involved in project delivery (Chen & Manley, 2014). The primary purpose behind these governance mechanisms is to improve performance outcomes while harnessing goal alignment objectives (Chen & Manley, 2014). These processes develop stronger team relationships around common goals and enhance performance outcomes (P. Davis & Love, 2011). This discussion leads to the hypothesis below:

Hypothesis 1: *Individual performance in partnered-projects is positively related to individuals' goal alignment perception.*

2.4.2 Teams of Teams

The notion of teams of teams is pervasive in practice if one takes a moment to assess the organizational landscape. Construction projects are ripe with teams of teams due to the way projects are delivered. As an example, a construction company may have several projects running concurrently each having a Project Director, Project Manager, Superintendent, Project Engineer, Safety Manager, and administrators. This comprises a team which is then joined with other similar team structures to deliver a construction project. Teams, like these, must work efficiently and effectively to accomplish complex tasks or goals.

For example, some partnered projects use focused action strategic teams (FAST) to facilitate quick and timely exchanges of ideas and information to resolve issues. These smaller subgroups, or teams of teams, are typically comprised of responsible work parties and are often divided by specific work scopes such as the quality control and assurance team. Meanwhile, outputs whether tangible or intangible are fruits from processes and are used to give feedback on how well performance objectives are met (Ilgen & Moore, 1987; Nadler & Tushman, 1980; Nadler, Mirvis, & Cammann, 1976). Performance conditions are concerned with quality, quantity, or other measurable outputs that are obtainable from processes. This information is used to provide performance feedback to individuals or teams.

Several factors are at play when teams work towards collective goals. The performance of the team can be constrained by team composition, work structure, task characteristics, and shared cognition among others (Salas, Cooke, & Rosen, 2008). It is, therefore, important to understand these various factors and how they relate to construction project teams.

Team composition largely consists of underlying attributes such as personality, cognitive ability, motivation, and cultural factors (Salas et al., 2008). One can only imagine the hosts of issues personalities may impose on team performance. For example, team performance is positively related to team conscientiousness, agreeableness, extraversion, emotional stability, and openness to experience (Mathieu, Maynard, Rapp, & Gilson, 2008). Therefore, team performance can be restricted when team members lack some of these key attributes. Cognitive ability, however, has varied implications regarding team performance. It is positively related to learning performance during task execution when the workload is evenly distributed and when task-related knowledge is desired over longer time frames. Conversely, cognitive ability is less credible when the team structure is not appropriate for the tasks (Mathieu et al., 2008).

Team norms, communication structure, and even work assignments can also affect team performance. These factors underlie the work structure under which teams operate (Salas et al., 2008). An effective communication structure is imperative to a successful project team. One type of communication structure is that of a transactive memory system (TMS). A TMS, developed by Wegner (1987), is a cooperative system to store, retrieve, and communicate information for person to person (Lewis, 2003). This communication structure allows a team to efficiently coordinate, communicate, and access specialized knowledge of individuals.

In the AEC industry, the implications of team cognitive processes and emergent states are easily evinced. Project teams come together for the common purpose to complete a project based on owner requirements communicated and executed by many different organizational units. During the traditional delivery processes (e.g., design-bid-build (DBB),) effective teams struggle to establish common goals and objectives, freely share information, remain open to input from all team members, and work seamlessly across organizational boundaries (Baiden, Price, & Dainty, 2006). It is a necessity for multidisciplinary teams to integrate knowledge from different domains, yet, is hindered due to misaligned cognitive processes which are seemingly complex (Kotlarsky, van den Hooff, & Houtman, 2015). Although this working system has persisted for many years, the construction industry lacks effective teams (Baiden & Price, 2011).

The emergent cognitive process within FAST teams is team mental models (TMM) and transactive memory systems (TMS). A TMM can be thought of as convergent knowledge representation regarding information held in common by a team (Mohammed, Ferzandi, & Hamilton, 2010). It is likely executive teams experience a TMM whereby everyone has a shared understanding of project goals and objectives. Furthermore, the TMM can help them efficiently access information necessary to execute tasks such as deciding on a particular heating, ventilation, and air conditioning (HVAC) system that satisfies both design intent and stakeholder requirements. As a project moves into construction, a TMS develops within the core project team.

It is this distributed knowledge structure that allows the core team to rely on the specialized expertise of all team members and to coordinate information flow. An example TMS is exhibited during a meeting to review an electrical equipment submittal which includes the owners' team, project managers from the contractor team, and design team engineers. Each party is anticipated to provide information in the review process based on their specialized area of knowledge. Design changes or inadequate designs are marginalized during these team submittal review processes where expectations are coordinated, clearly communicated, well-defined, and received by everyone. Moreover, in these instances, all project stakeholders are able to provide feedback and insights based on their knowledge, skills, abilities, experience, and other tacit knowledge.

2.4.3 Feedback Processes and Theory

Feedback serves multiple purposes ranging from error-correction to identifying problems and providing clarity for goals (Nadler, 1979). For team members to allocate cognitive and behavioral resources to tasks, DeShon et al., (2004) suggest feedback should be specific to individuals or their subsequent teams, but not both. In this self-regulatory process, individuals compare feedback information against individual goals and team goals. Then, a behavioral choice is made to prioritize the level of effort and strategy expended towards these goals ultimately affecting performance outcomes.

To achieve benefits from feedback individuals working in teams must receive, process, and react to the feedback mechanism. This is often problematic when the feedback frequency is irregular or infrequent; however, learning from feedback is contingent upon project risk levels, evolves over the project lifecycle, and across projects (Manley & Chen, 2015). Thus, in AEC partnered projects feedback is provided systematically based on key project factors such as cost, size, complexity, and duration (Gransberg et al., 1999). These feedback monitors are set by the team early when project goals are identified and when decisions are made to use a neutral third-party facilitator.

Feedback intervention theories are not unified on the effect feedback has on performance. According to Kluger and DeNisi (1996), the relationship between feedback and behavior is complex and often contradictory in its interpretation. The feedback body of literature, also known as feedback intervention, commonly asserts that feedback intervention improves performance despite varied results over its nearly 100 years of research. In particular, some researchers have found feedback intervention has no effect, negative effects, or debilitates performance altogether. To address this dilemma, Kluger and DeNisi (1996) conducted a meta-analysis in order to document the state of the literature, properly unify feedback intervention theory, and to integrate existing theories into a new feedback intervention (FI) theory.

Feedback intervention theory merges components and ideas from the following theories into a singular theory: control theory (Annett, 1969), goal setting theory (Locke & Latham, 1990), action theory (Frese & Zapf, 1994), action identification theory (Vallacher & Wegner, 1987), multiple-cue probability learning paradigm (Balzer, Doherty, & O'Conner, 1989), social cognition theory (Bandura, 1991), and portions of learned helplessness theory (Mikulincer, 1994). In doing so, they offer five basic arguments for feedback intervention theory: 1) Behavior is regulated by comparisons between feedback to goals and standards, 2) goals or standards are hierarchically organized, 3) feedback-standard gaps that receive attention are active in behavior regulation processes because attention is limited, 4) generally attention is directed towards moderate levels in the hierarchy, and 5) feedback interventions shift the focus of attention and impacts behavior. Based on these conjoined theories and assumptions, they assert FI induces task motivation, task learning, and meta-task processes.

Whether investigating feedback from the perspective of goal-setting or control theory, the behavior is directed towards goals or standards. Feedback (i.e., intervention or not) allows people to evaluate their performance with respect to goals or standards. This comparative inspection results in a feedback sign relative to the goal (e.g., positive or negative sign in relation to the discrepancy between performance and goal). Several options are available to individuals in response to the feedback-standard discrepancy. One can eliminate the discrepancy, according to control theory, by changing behavior so future feedback is adjusted, change goal or standard to align with present feedback, refuse feedback, or avoid the situation (i.e., physically or mentally). Similarly, goal setting theory maintains people may respond to feedback-standard discrepancies by striving to achieve the goal, change the goal, refuse feedback, or abandon commitments one has made to goals.

Available literature and recent research has examined effective teams in the context of AEC, where well-defined concerns with communication, trust, and collaboration are illuminated (Chan, Chan, & Ho, 2003; Cheung, Ng, Wong, & Suen, 2003; Dewulf & Kadefors, 2012; Larson, 1997; Naoum, 2003; Xue, Shen, & Ren, 2010). Research into AEC partnering purports workshops consisting of feedback or partnering health indexing (Puddicombe, 1997) offer direct information as to the current effectiveness of the arrangement (Cheung, Suen, & Cheung, 2003; Mollaoglu et al., 2015). With this in mind, it is important to understand how underlying team knowledge processing systems (TMS) interact with the level of commitment and self-efficacy of individuals when seeking to achieve team goals. This leads to the second hypothesis for this study:

Hypothesis 2: *Individuals' TMS moderates the relationship between individuals' goal alignment perceptions and individual/team performance in partnered-projects.*

2.5 Transactive Memory Systems

Lewis (2003) describes TMS as "the active use of transactive memory by two or more people to cooperatively store, retrieve, and communicate information". The notion of shared memory systems was spawned by (Wegner, 1987), who first observed how groups in close relationships have implicit knowledge of one another's memory. This memory system is structured such that it is easily retrieved from others when needed hence; a transactive memory system is greater than the sum of its parts or individual memories (Wegner, Erber, & Raymond, 1991).

A TMS entails a shared division of cognitive labor regarding encoding, storing, retrieving, and communication information from different subject experts (Hollingshead, 1998b; K. Lewis & Herndon, 2011). This system efficiently ensures new information entering a group is properly allocated to the correct member who is responsible for it. This information is added to the pertinent knowledge already held by the member and is available to be quickly retrieved, communicated, and integrated with the tasks related knowledge when needed by the group.

Kyle Lewis (2003) put forward three categories to discern a TMS as specialization (i.e., the differentiated structure of members' knowledge), credibility (i.e., members' beliefs about the reliability of other members knowledge), and coordination (i.e., effective and well-orchestrated knowledge processing system). These categories are used to aggregate individuals' perceptions to create a team score of TMS. This measurement offers a unique approach to diagnose integration within teams.

Theory and research suggest TMS facilitates quick and coordinated access to specialized expertise, thereby improving group performance. The performance attributed to TMS is explained by the unique knowledge structure that develops. More importantly, this depository of knowledge is coded and stored in a systematic process that allows for easy retrieval or elicitation from group members. An effective TMS is further enhanced by the dynamic interplay as teams communicate, interact, and execute tasks in groups (Lewis & Herndon, 2011). As a result of this guidance, this study contends team theory is useful to explore the association between partnered project feedback during collaborative project delivery and performance outcomes.

2.6 Project Teams in the AEC Industry

Forming teams that work well together is commonly ascribed to the success of projects. From an organizational perspective, Hoegl and Gemuenden (2001) establish performance measures of team collaboration using communication, coordination, balanced member contributions, mutual support, effort, and cohesion as measurement indicators. In their opinion, perceptions of team performance are directly related to teamwork qualities and those of team leaders and managers. Similarly, Suprapto et al. (2015) purport how key teamwork qualities, as these, serve as mediators in regards to relational attitudes, collaborative practices, and joint capability with project performance in construction projects. However, the effectiveness is constrained when collaborative practices become formalized and results are taken for granted (Bresnen & Marshall, 2002). In spite of this, it is becoming more apparent that collaborative working arrangements, such as partnering, hold clear implications to help increase the efficacy of project teams. In particular, those working across organizational boundaries.

2.6.1 Team Integration

Construction projects are inherently filled with risks and commonly rely on the contracts to help spread the risks across its participants. It is challenging to account for all unforeseeable risks ahead of commencing work, thus contract conditions have been traditionally used. Traditional contracts work against joint risks management necessary post contract stage when challenges are encountered extending beyond the contract language (Rahman & Kumaraswamy, 2004). Thus, collaborative working arrangements surfaced to encourage team integration and to deal with decades filled with adversarial mentalities among fragmented construction processes (Lahdenperä, 2012).

The concept of integration has taken on several meanings in the AEC industry. The term "integration" emerged within the industry in the 1990s centered on computer integrated construction (Betts, Fischer, & Koskela, 1995). The premise of computer integrated construction was the implementation of technologies which could facilitate frequent data and knowledge sharing among project participants (Teicholz & Fischer, 1994). Through this, they explicated several goals for computer integrated construction to achieve its aim such as the rapid deployment of high-quality designs, quick and cost-effective construction with the ability to deliver data and models to the end users of the facility. Integration, according to Teicholz and Fischer (1994), begins with integrated computer applications that allow for concurrent design and construction.

The use of integration continued to progress from computer integrated construction to team integration. In its original context, integration was explained as the "the free exchange of information between different project participants in the construction process" (Baiden, Price,

& Dainty, 2003). Integration has also been defined as the “merging of various disciplines with different individual or organizational goals, cultures, and needs into a single cohesive unit focused on shared project goals or tasks” (Jaafari & Manivong, 1999). Although many different definitions persist, its purpose remains the same being to align project teams into cohesive and collaborative units with common objectives. A fully integrated team, according to Baiden et al. (2003), includes the client/owner team and is considered a team of teams with clearly defined skills and professional roles necessary to satisfy project objectives. This integrated team is best achieved by incorporating contractually binding agreements such as dispute resolution ladders to help resolve conflicts into collaborative contracting arrangements (Gransberg & Scheepbouwer, 2015).

Recent literature on team integration and collaboration demonstrate an emerging area of research within construction project teams (Comu et al., 2013; B. Franz et al., 2016). Team integration theory is well-documented in other areas such as organizations, sports, military, and academics (Chiocchio & Essiembre, 2009). Yet, construction project teams are ripe with information that can inform theory based on common understandings of social dynamics. Thus, researchers are attempting to better understand the role of integration, group cohesion, and transactive memory systems as they relate to project performance occurring during collaborative working approaches (Comu et al., 2013; Franz et al., 2016).

Franz et al. (2016), explores a sample of 204 completed projects following different delivery methods to compare cost, schedule, and quality performance. They assert the literature is disparate, or according to Davis (1971) not well-organized in which project delivery methods are most appropriate for team integration and the extent integration affects performance outcomes. As with this study, they insist the *how* and *why* are generally not explored when thinking about this relationship. Thus, the data in their study is analyzed to explore these relationships against different delivery methods.

Two distinct theories are a priori in their work, group cohesion, and team integration. In their opinion, team integration consists of interfirm interactions and shared culture that is developed during project delivery. Meanwhile, group cohesion is the point at which a new identity is established and the team members join together in a common culture committed to project goals while also trusting, respecting, and clearly communicating as a team. Using these two theories, the researchers investigate mediators between project delivery and performance.

Franz et al. (2016) determined key components of project delivery methods influence team integration and group cohesion. Specifically, the timing of involvement from team members factors into whether team integration is achieved. Group cohesion is increased through cost transparency and procurement processes that place less emphasis on price but, rather focuses on qualifications or relational attributes. According to Franz and Leicht (2016), the literature is shifting in our understanding of project delivery approaches and how collaborative tools redefine traditional classifications. They separated established project delivery methods into latent classes such as Class I (i.e., Design-Bid-Build [DBB]), Class II (i.e., Design-Bid-Build with early procurement), Class III (i.e., Construction Management At-Risk [CMR]), Class IV (i.e., Design-Build [DB]), and Class V (i.e., Multiple DB and Integrated Project Delivery [IPD]). Thus, processes are equally important as the project delivery methods utilized for a project and influences team behaviors.

Comu et al. (2013) outlined another new perspective on collaborative working arrangements and a relationship to transactive memory systems (TMS). In their opinion, firms operating globally across geographical and other boundaries require unique strategies to overcome ambiguity. Virtual teams are also seeking to increase collaboration, despite their geographical distances as they are believed to inherently be more complex than traditional project networks. Thus, the researchers insist both technology and relational intervention (i.e., facilitators) affect project performance.

Comu et al. (2013) assert in their evaluation of global virtual project networks (GVPN) that facilitators affect performance outcomes so long as they deliver process feedback as opposed to project content. Stated differently, process facilitators engaged in content related discussions impact GVPNs performance working in virtual collaborative workspaces. According to Comu et al. (2013), the development of a cohesive TMS is related to collaborative effectiveness in the project network.

Using data from four simulated global engineering project networks, Comu et al. (2013) examine the development of cohesive subgroups. A strong cohesive network is posited to include higher frequency and duration of interactions during group collaboration, thus affecting performance. They compare ratios of nodes with ties within the subgroup against that of nodes outside the subgroup. These networks are also separated by facilitator versus non-facilitated groups. Interestingly, the findings are insightful in that facilitators did not help maintain nor support cohesive collaboration in TMS. Additional support for this findings is, therefore, available for future investigation. The second finding as a result of their work is that TMS development and cohesiveness are positively associated with non-facilitated networks.

Contrastingly, this study anticipates feedback via facilitation is positively associated with TMS development and/or cohesiveness, however, it is based on process facilitation rather than content facilitation.

The two aforementioned studies demonstrate a need to understand the key elements underlying collaborative working from a team theory perspective. The key components of collaborative working are 1) commitment; 2) cooperation and communication; 3) trust; 4) common goals and objectives; and a 5) win-win philosophy (Yeung et al., 2012). Commitment refers to a shared sense of ownership to project goals, objectives, and successful outcomes for all project team members. As can be expected, these essential elements are interrelated such that open and honest communication inspires trusting relationships to form within project teams. Meanwhile, establishing common goals and objectives helps to direct attention to controlling transaction costs associated with a project (Walker & Chau, 1999). A team focused on common goals and objectives reinforces other attributes beneficial to increased collaboration and project success.

Other supporting elements found within AEC literature are 1) agreed-upon problem resolution methods; 2) continuous improvement strategies; 3) facilitated workshops; 4) equitable risk-reward structure; 5) declared statement of common objectives; 6) agreed-upon gain-sharing/pain-sharing or bonus incentive program; and, 7) formal contract to which binds all parties to the agreements (Yeung et al., 2012). These core elements and supporting attributes are typically found in contracting approaches bent on developing integrated project teams such as IPD, strategic or project alliancing, and project partnering. Yet, it is the shared knowledge and information processing system that helps the teams pick up efficiencies and increase their performance. Interestingly, outputs from collaborative processes will impact team effectiveness. For instance, consistent engagement from top management, integrity monitoring using team scorecard surveys, team empowerment, and feedback in the form of acknowledgment and/or celebrations are processes that are likely to influence individual behaviors and build trust (Pishdad-bozorgi & Beliveau, 2016).

2.6.2 Goal Alignment

Team regulatory and goal alignment processes determine the amount of behavioral resources one will allocate to team performance goals (Kozlowski & Ilgen, 2006). The use of scorecards serves as early warning indicators to the project team. This information can be used to provide genuine acknowledgments to thank team members for their contributions. Moreover, can affect team goal alignment and motivation towards team performance outcomes. This understanding asserts a bottom-up approach to increasing team effectiveness, rather than top-down through contractual project delivery methods.

Collaboration between different organizations is critical to accomplish common goals and factors heavily into performance outcomes (Dietrich et al., 2010). According to Dietrich et al. (2010), there are five high-quality characteristics demonstrated in collaborative projects being: communication, coordination, mutual support, aligned efforts, and cohesion. These characteristics are generally present among project teams when agreed-upon goals are established, clear and open conflict resolution strategies are used, and effective communication systems are employed. They assert, other characteristics are joint problem solving, trust, and goal congruence are all present within collaborative project teams. Thus, these teams may adjust their behavior in the relational exchanges with other organizations based on the feedback received. Under close monitoring intended to provide feedback, party's may resist and begin concealing underlying motives focused on their organizations' goals as opposed to those of the team (Stephen & Coote, 2007). This occurs when formal and explicit language is not included in contracts. In fact, Stephen and Coote (2007) argue that relational behaviors are best aligned with goals when supportive leadership is involved.

Generally, team effectiveness and integration have been attributed to specific project delivery methods (Mollaoglu-Korkmaz, Swarup, & Riley, 2013). In contrast, Franz and Leicht (2016) offer an alternative taxonomy of project delivery methods which explains how they share common characteristics and can be situated within one of five emerging categories. These characteristics are used to reorganize delivery types based on the timing of contractor involvement in design stages, procurement strategy, contractual arrangements with the owner, contractor selection and award criteria, and payment terms establish the various delivery approaches.

With this in mind, construction project team integration and cohesion are clearly influenced by these characteristics (Franz, Leicht, Molenaar, & Messner, 2010). For example, early involvement of contractors in the schematic design phase helps integrate their knowledge and experiences into decisions that ultimately affect the teams' performance on a project. This suggests that increased team integration and cohesion is not confined to specific project delivery methods, rather results from manipulated team behaviors effectuated by owner decisions. Another alternative explanation is whether collaborative practices adopted for projects are the right fit, especially considering how feedback levels and, subsequently, the collaborative experience of project teams may vary when these practices are followed.

2.6.3 Collaborative Working Arrangements

The construction industry generally relies on relational/collaborative project delivery arrangements to facilitate better goal alignment between project teams and project objectives (Zuo, Chan, Zhao, Zillante, & Xia, 2013). Project delivery approaches such as IPD and project partnering emerged in the US in 1998 and 2005, respectively (Lahdenperä, 2012). These multi-party contracting practices seek to increase team integration and owner value while reducing waste and inefficiencies during project delivery (Lahdenperä, 2012; Pishdad-Bozorgi & Beliveau, 2016). The underlying motivation behind collaborative project delivery arrangements is to spread risks and rewards evenly among project stakeholders (i.e., owner, design, and contractor).

Project delivery approaches such as IPD and project partnering clearly incorporate collaborative practices and processes that affect organization and management strategies, contracts, project team communications and their behaviors. Pishdad-bozorgi and Beliveau (2016) separated the following processes, referred to as traits, into four categories:

1. Organizational and Management Strategies
    a. Early involvement of key participants
    b. Jointly developed project target criteria
    c. Collaborative decision making
    d. Intensified early planning and design
    e. Champion/facilitator
    f. Building Information Modeling (BIM)
    g. Lean construction
2. Contract
    a. Multi-party contract

    b. Relational contract
    c. Shared financial risk/reward based on project outcome
    d. Risk identified and accepted early
    e. Liability waivers between key participants
3. Communication
    a. Open communication
    b. Colocation
    c. Information sharing
4. Behavioral
    a. Transparent financials (Open book accounting)
    b. Mutual respect, trust, and collaboration
    c. Pre-existing relationships between parties
    d. Lean culture

Many of these processes and/or traits behold feedback signals that change individual and team behaviors during collaborative delivery. The success of both the team and project can suffer, as a result, when not completely aligned.

Collaborative approaches such as IPD, Lean construction, and project partnering share many similarities which encourage collaboration and influence the extent to which goal alignment occurs within project teams. Although, several differences persist with project partnering such as the use of benchmarking, partnering workshops, and partnering sessions. These collaborative practices implemented during partnered project delivery provide more performance related feedback as opposed to process feedback which is also critical to help regulate behaviors.

Goal alignment is engaged by involving key participants early on and jointly developing project goals which build collaboration and trust. In this manner, project teams begin to align their knowledge and intentions with those of the project, rather than working from individual silos (Pishdad-bozorgi & Beliveau, 2016). From a contractual standpoint, holding multiparty agreements that include shared risks and reward structures militate against traditional emphasis placed on transaction costs. This inconspicuous feedback signal shifts individuals' mindset towards innovation, especially when their success is contingent upon that of the entire team (Lahdenperä, 2012).

Lean construction is another example of collaborative working arrangements that help project teams overcome project complexities, uncertain conditions, and competing goals often found among diverse teams (Maturana, Alarcón, Gazmuri, & Vrsalovic, 2007). According to The Lean Construction Institute (2016), there is a concerted effort within the construction industry to continuously improve, generate value, remove waste in processes, work on flow efficiency, and optimize the whole construction project delivery process. The underlying goals are to always maintain respect for people involved in the project.

The motivation behind Lean construction is to minimize waste and increase performance using strategies such as building information modeling (BIM), *The Last Planner System* (LPS), value stream mapping, target value design, and set based design (Smith, Mossman, & Emmitt, 2011). BIM is an information-rich 3D modeling software tool that allows project teams to virtually build a construction project ahead of physical construction. Tools like BIM help to integrate design and construction teams delivering more value for owners. Meanwhile, LPS is a "construction specific system designed to improve production predictability in project-based environments (Smith et al., 2011).” The system builds trust among project teams by holding people accountable to promises made to other members of the project team. It is this ability to keep commitments that create a feedback loop, increasing cohesion and, ultimately, affects performance outcomes.

Value stream mapping is a process to determine the current value-added stream of the project to identify and eliminate waste. The process optimizes the design as part of project delivery and helps to avoid reworking that typically occurs later on during construction. Target value design is used to get early stakeholder involvement in the design process focused on value creation while remaining cognizant of the customer’s budget. In the meantime, set-based design is a process whereby stakeholders and subject matter experts (SME) work to develop a various solution to product and production design problems and decide on a solution at the last responsible moment as a team. When used, set-based design permits concurrent design options to develop from which the project stakeholders can choose from. Each of these Lean construction processes, according to Smith et al. (2011), inherently require intense communication and collaboration.

In project partnering, another collaborative working arrangement, FAST teams are assembled to resolve change issues and problems occurring during construction processes. There may be executive teams (e.g., top management from owner, contractor, and design companies), core teams (e.g., field project managers from respective organizations), or stakeholder teams (i.e., end-user groups both internal and external to the project) all of whom participate in joint workshops (International Partnering Institute (IPI), 2016). Team cohesion begins to take place during these ongoing workshops, although this may be limited during team formation (Salas, Grossman, Hughes, & Coultas, 2015). Therefore, the frequency of partnering workshops permits greater team cohesion as they move through the phases of team development. This dynamic process, according to Kozlowski and Ilgen (2006), emerges as teams "do things" or "make decisions" to resolve task driven problems.

This active intervention and synergistic environment promotes collective planning, organizing, and controlling of the project goals and objectives. In the event changes do occur, teams are able to de-couple tasks to minimize project impacts. However, a larger group of people working to review and approve a submittal may experience social loafing (i.e., reduced effort and motivation while working collectively as opposed to individually) within the team (Lam, 2015). When this happens the overall performance of the team can be affected, especially if team members in the field fail to offer tacit knowledge based on their experience since they are closest to the actual work. Collaborative approaches like partnering aim to bridge certain dilemmas using tools such as formalized partnering charters which empower all team members to participate, remain open-minded, to ask questions and also commit to having fun during the entire partnering process.

2.7 Study Propositions and Theoretical Framework

The propositions presented below are used to investigate the ***partnered-project level*** research questions qualitatively. Figure 1-3 shows the propositions for the relationship between project risk factors, collaborative project delivery practices, and project performance.

Proposition 1: *Project risk factors and the level of collaborative project delivery practices in partnered-projects are positively related;*

Proposition 2: *Collaborative project delivery practices and individuals' goal alignment perceptions in partnered-projects are positively related; and,*

Proposition 3: *Individuals' goal alignment perception and project performance in partnered-projects are positively related.*

Separately, Figure 2-4 shows the proposition for the asserted cross-level interaction in this study.

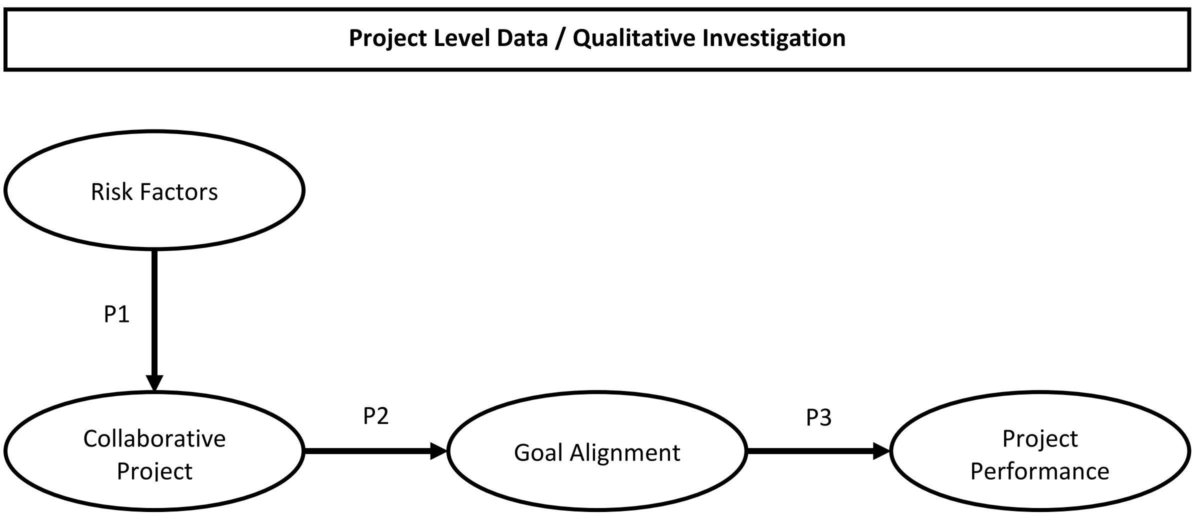


Figure 2-4: Relationships and propositions between project risk factors, collaborative project delivery practices, and project performance

2.8 Study Hypotheses and Theoretical Framework

The hypotheses intended to quantitatively test the theoretical model and relationships among the variables at the ***individual/team level*** of analyses are given below. These are specifically used to estimate the direct and moderating effects between *goal alignment*, *TMS*, and *performance* measured during partnered-project delivery. The hypotheses are shown in Figure 2-5 and described below.

Hypothesis 1: *Individual performance in partnered-projects is positively related to individuals' goal alignment perception.*

Hypothesis 2: *Individuals' TMS moderates the relationship between individuals' goal alignment perceptions and individual/team performance in partnered-projects.*

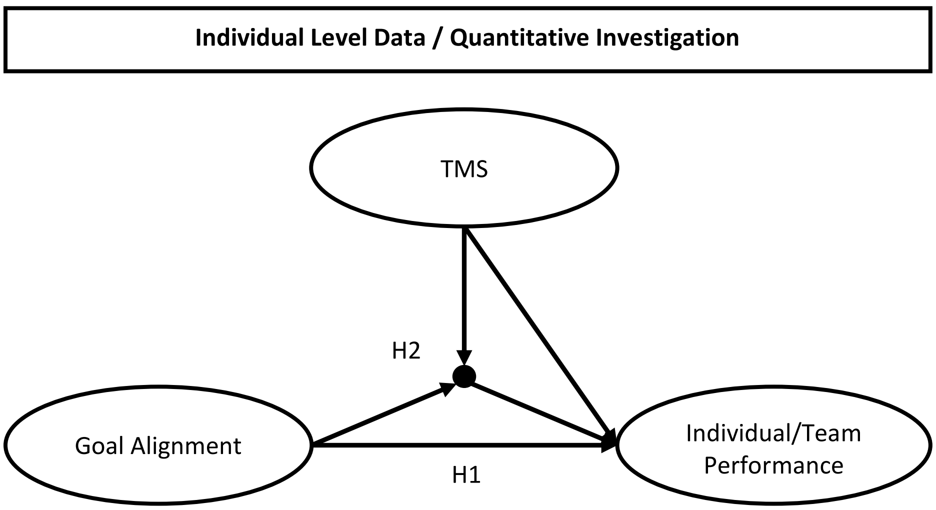


Figure 2-5: The relationship and hypotheses between goal alignment, transactive memory systems, and individual/team performance

2.9 Summary

Collaboration is becoming a central idea and expectation within the construction industry even though discontinuities exist between projects. The characteristics and risk associated with the project offer clues to understand whether a well-coordinated knowledge and information systems (TMS) moderates the effects of goal alignment on performance outcomes. Based on the literature, a need exists to parse out the structural component of teams that cause the variations in this link. The literature often alludes to a strong connection between collaborative project delivery approaches and improved project performance, yet frequently fails to critically inspect the behavioral aspects of teams. Thus, this study fills this gap by identifying how project risk factors and collaborative project delivery practices influence these relationships. Moreover, this study firmly establishes the relationships among *goal alignment*, *TMS*, and *performance outcomes*. The methodology followed to achieve the aims of this study are described in the next chapter.

CHAPTER 3 METHODOLOGY

This chapter presents and describes the research methods used in this study. This study uses a mixed-methods approach to understand the overarching research question "*how do collaborative project delivery practices affect goal alignment and performance in AEC project teams*." A gap exists in the AEC literature, demonstrating a need to identify the underlying attributes of collaborative project delivery approaches which result in better performance. Focusing on partnered-projects as a type and subset of collaborative AEC project delivery approaches, this research examines multilevel data via multiple-case study evidence. A brief review of the research questions is presented, followed by the methodological steps required to address the research questions.

3.1 Introduction

Few of these studies, until recently, have examined how team related factors are related to project performances in the context of AEC project teams (Comu et al., 2013; B. Franz et al., 2016). A gap exists in the AEC literature to advance this topic, in particular, the role goal alignment and TMS have in the project delivery process. Based on the literature, goal alignment perceptions among AEC project teams and cohesive transactive memory systems are important for individual, team, and project performance. Thus, this research intends to address the following research questions: "*how goal alignment affects performance in AEC project teams when collaborative project delivery practices are followed*."

<u>Project Level Questions</u>*: What collaborative project delivery practices impact project goal alignment in partnered-projects? Do project risk factors impact collaborative project delivery*

practices and, thus, goal alignment? What are the relationships between project risk factors, collaborative project delivery practices, and goal alignment in partnered-projects? Does goal alignment affect project performance?

Individual-level Questions: *Does goal alignment affect individual performance? If so, is this relationship moderated by TMS?*

In the AEC literature, a need exist to identify the underlying attributes of collaborative project delivery approaches which result in better performance outcomes. To respond, several goals and objectives are established and reiterated next.

3.2 Research Goals and Objectives

The primary aim of this research is to explore the relationships between project risk factors, collaborative project delivery practices, goal alignment, transactive memory systems (TMS), and performance outcomes in AEC project teams. Focusing on partnered projects as a type and subset of collaborative AEC project delivery approaches, the specific objectives of this study are to develop:

1. Develop a framework demonstrating the relationship between project risk factors, collaborative project delivery practices, goal alignment, TMS, and performance outcomes by;

    1. Qualitatively examining the following at partnered-project level:

        i. The links among *project risk factors*, *collaborative project delivery practices*, and *project performance*; and,

2. Quantitatively examining the following at individual-level in interorganizational AEC project teams:

    i. The relationship between *individual/team performance*, *goal alignment,* and *TMS*.

2. Test an evaluation metric for *goal alignment* and utility of *TMS* metric to investigate AEC collaboration during project delivery;

3. Help facilitate collaborative contracting in construction projects by identifying key characteristics individuals' and projects' have in common.

4. Provide theoretical contributions to AEC literature understanding collaborative project delivery methodologies as a form of relational governance.

3.3 Selecting the Research Strategy

Sound empirical research is grounded in a strong understanding of pertinent literature, identifying the gaps for research, and positing an "interesting" research question to fill the gap (M. S. Davis, 1971; Eisenhardt & Graebner, 2007). According to Yin, (2003), various strategies are available to researchers which can help answer the research question. The different strategies are unique to the research question explored. These research strategies are experiments, surveys, archival analyses, history, and case studies. Experiments are intended to test impacts of intervention on an outcome while controlling for other external factors using a control and experiment group (Creswell, 2009). Given that partnered construction projects are unique endeavors, it is challenging to randomly assign individuals to distinct control and experiment groups to assess effects across AEC project teams and projects. Therefore, multiple case studies are investigated to explore project team dynamics within the context of partnered-projects. In this format, both qualitative (e.g., partnering charter, partnering scorecards, project meeting minutes, partnering session documents) and quantitative (e.g., surveys) data are available.

The mixed-methods research approach followed in this study builds upon an emerging perspective to understand interorganizational project teams in AEC literature and analyze subsequent data (Korkmaz, 2007). In this study, individuals are embedded within teams (e.g., owner teams, design teams, and contractor teams) and teams are nested within case study projects. Therefore, three levels of analyses become pertinent in this study, individual-level, team level, and project level. According to Yin (2003), multiple units of analysis offers greater flexibility to inspect data for consistent patterns across units and cases. Moreover, mixed-methods enables researchers to use two or more types of data collection and data analysis methods (i.e., quantitative, qualitative). These data are used to integrate findings and draw inferences from a single study or theoretical perspective (Miller et al., 2011). Another advantage of mixed-methods is the ability to triangulate the findings of multiple forms of data, quantitative and qualitative (Campbell & Fiske, 1959).

Project-specific data such as collaborative project delivery practices (e.g., use of partnering charters, scorecards, workshops) and project team rosters are collected from main project participants (e.g., partnering facilitator, owner representative, or Construction Manager/General Contractor (CM/GC) project manager). Structured interviews are performed to collect data from key stakeholders representing the owner team (e.g., owner, owner representative, or other key stakeholder involved in project delivery) regarding project performance outcomes (e.g., cost, schedule, quality, and conflict resolution). Project-level data are collected using a qualitative approach. These project-level data are analyzed in parallel with survey data using pattern-matching, content analysis, and cross-case synthesis to help integrate findings. Meanwhile, project risk factors and collaborative project delivery practices become fixed effects in quantitative analyses.

Quantitative data, via project rosters, are gathered from surveys administered at or near project completion. Data collected from surveys are used to measure individuals' perceptions of goal alignment, TMS, and performance outcomes. This research design permits group comparisons (e.g., owner teams, design teams, and contractor teams) and statistical testing using factor analysis and multivariate regression/correlation analysis (MRC). These data are also aggregated forming group mean scores to inspect team level effects within case study projects.

3.4 Research Process

A partnered project delivery framework and relevant literature guide the methodology for this research. The steps forming the research process followed in this study is illustrated in Figure 3-1, along with the chapter in which it occurs. The steps for this research include reviewing the literature, selecting the research strategy, developing construct measures, data collection procedures, data analysis, model validation, results from both cross-case synthesis and multivariate regression analyses, then, findings and conclusions.

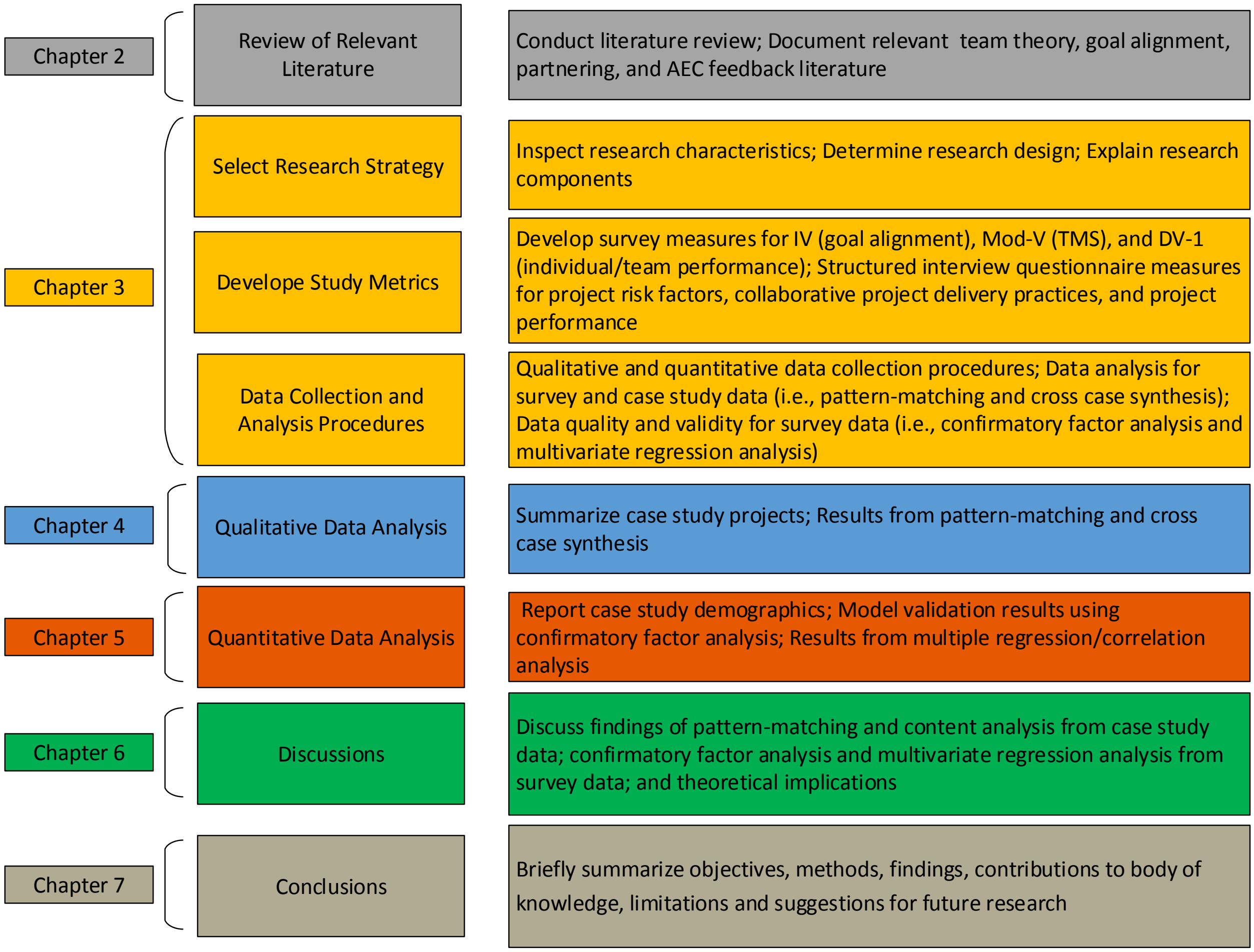


Figure 3-1: Research process and steps followed in this study.

3.5 Study Population

The population considered for this study consists of project participants and stakeholders involved in construction projects working under partnering arrangements in the U.S. The objective is to collect data from partnered-projects and their subsequent project teams. The project teams are represented by owners, design engineers, contractors, and subcontractors. The final study participant sample (n) size was 125 potential survey respondents from six case study projects. Survey data were collected beginning in January 2018, over a period of three months.

3.6 Study Metrics

The mixed-methods research followed in this study uses metrics based on extensive investigation of team theory and AEC partnering literature. This study investigates relationships for the conceptual multilevel model which suggests individual/team AEC project team members' assessment of *goal alignment* (i.e., independent variable) affects *individual/team performance* (i.e., dependent variables), yet is moderated by *TMS* (i.e., moderator variable). The project level model purports a clear relationship existing between *project risk factors*, *collaborative project* delivery methodologies, and *project performance outcomes* in partnered-projects. One key team theory, transactive memory system is a sub-domain of SMM thus is accessible for measurement using similar strategies (Mohammed, S., & Dumville, 2001). For example, the shared mental model construct contains three characteristics that permit measurement. These characteristic are *elicitation*, *structure representation*, and *representation of emergence* (DeChurch & Mesmer-Magnus, 2010).

The measurement approaches help interpret the extent of convergence or similarity among team members' knowledge (Mohammed, Klimoski, & Rentsch, 2000). *Elicitation methods* capture the content of the model using similarity ratings, card sorting tasks, concept mapping, or rating scales (DeChurch & Mesmer-Magnus, 2010). The elicitation method parses key elements of the team's task to understand the content based on participants responses. *Structure representation* is used to illustrate agreement regarding the similarity of team members as it is represented in a model (DeChurch & Mesmer-Magnus, 2010; Mohammed et al., 2000). While Kozlowski and Klein (2000) suggest *representation of emergence* responds to the overall climate measuring both the content and strength of consensus at the focal level of analysis.

This study used the *elicitation strategy* to understand whether a strong TMS is present within partnered-project teams. The independent variable in this study is goal alignment while transactive memory system is a moderator variable of individual, team, and project performance. Performance constructs are the dependent variables that will be investigated in this study. These data will also be aggregated to form a group mean for team level analyses. The latent constructs in this study entail both formative and reflective indicators.

Reflective indicators are observed variables perceived as reflective (i.e., effect) indicators of an underlying construct or latent variable (e.g., TMS, personality, attitude, etc.). In contrast, formative indicators are observed variables perceived as formative (i.e., cause, causal) indicators that are assumed to cause a latent variable (e.g., Socio-economic status (SES), etc.) (Diamantopoulos & Winklhofer, 2001). This study assesses quantitative data regarding *goal alignment, TMS, individual/team performance* using reflective indicators associated with reliable metrics in team literature (Hoegl & Gemuenden, 2001; Jap, 1999; Kyle Lewis, 2003). Most of the items are assessed using a five-point Likert scale (e.g., 1-strongly agree to 5-strongly disagree) or by answering multiple choice questions (e.g., role in the project) within the survey. Meanwhile, qualitative data on *project risk factors*, *collaborative project delivery practices*, and *project performance* are measured using formative indicators resulting from the AEC literature.

3.6.1 Study Metrics for Qualitative Data

The following sections are used to describe the constructs and metrics for qualitative data collected in this study. The constructs are *project risk factors*, *collaborative project delivery practices*, and *project performance*.

3.6.1.1 Project Risk Factors

Project risk factors are assessed using best practice guidance and AEC literature which assert key attributes involved in the effectiveness of partnering (Gransberg et al., 1999; IPI, 2016). Utilizing these risk factors, structured-interview questions are developed to ascertain the desired level of partnering anticipated for the project. This allowed the researcher to determine how risk factors are related to collaborative project delivery practices, individual/team, and project performance. The variables and measures used to investigate project risk factors are displayed in Table 3-1. These variables are assessed using a scoring system to differentiate between certain factors such as project risks with potential impacts on cost/time, complexity, and political significance. To do so, each category is scored from 1-Not important to 5-Very important. The questions also include a contextual portion related to the specific case study project. As an example, schedule risks with potential impacts on cost/time includes options to select from such as none, limited, and many.

Table 3-1: Measures used to assess common project risk factors (Gransberg et al., 1999; IPI, 2016).

Common Project Risk Factors: Evaluation Method						
		Not important=1 to Very important=5				
Number of project risks with potential impacts on cost/time (e.g., complex design and construction, public-private partnership, compressed schedule, uncommon materials, etc.)	☐ Few ☐ Moderate ☐ Many	1	2	3	4	5
Schedule risks with potential impacts on cost/time (e.g., liquidated damage and/or incentives)	☐ None ☐ Limited ☐ Many	1	2	3	4	5
Project team relationships	☐ Team has worked together before and has solid partnering foundation ☐ Team has no prior experience working together but has partnering foundation ☐ Team worked together before but no partnering foundation ☐ Team has not worked together and has no partnering foundation	1	2	3	4	5
Team partnering experience	☐ Experienced ☐ Some experience ☐ Most team members new to partnering	1	2	3	4	5
Political significance and community interest	☐ High visibility (significant strategic project) ☐ Probable (organization image at stake) ☐ Likely, depending on the size of the client and place of importance ☐ Unlikely, unless in a place of importance	1	2	3	4	5
Complexity	☐ High (i.e., highly technical and complex design and construction; short timeline/ schedule constraints, uncommon materials, new supply chain, etc.) ☐ Increased ☐ Moderate ☐ Standard	1	2	3	4	5
Project Delivery Method	☐ DBB ☐ DB ☐ CM/GC ☐ CMR ☐ Other	1	2	3	4	5

Each measure of *project risk* shown in Table 3-5 is given a score using the following equation:

$$\sum_{ij=0}^{n}(X1_{ij} + X2_{ij} + X3_{ij} + X4_{ij} + X5_{ij} + X6_{ij}) * 0.2 * \frac{100}{6\ (Total\ \#\ of\ Category\ responses)}$$

In the equation above, the response options for each variable are:

- $X1(Project\ risks) =$ (1) Few, (2) Moderate, or (3) Many
- $X2\ (Schedule\ risks) =$ (1) None, (2) Limited, or (3) Many
- $X3\ (Team\ relationships) =$ (1) Team and partnering experience high, (2) Team experience low and partnering experience high, (3) Team experience high and partnering experience low, or (4) Team and partnering experience low
- $X4\ (Partnering\ experiece) =$ (1) Experienced, (2) Some experience, (3) Most team members new to partnering
- $X5\ (Political\ significance\ and\ community\ interest) =$ (1) Unlikely, (2) Likely, (3) Probable, or (4) High visibility
- $X6\ (Complexity) =$ (1) Standard, (2) Moderate, (3) Increased, or (4) High

3.6.1.2 Collaborative Project Delivery Practice Construct

Collaborative project delivery practices are measured using metrics developed in a partnered-project delivery framework and AEC literature review (Mollaoglu & Sparkling, 2015). Based on the literature, some of these practice elements are the use of partnering workshops for project teams, establishing mutual goals and objectives, and project surveys to monitor partnering processes (Chan et al., 2004; D Hughes, Williams, & Ren, 2012; Deborah Hughes et al., 2012). These formal and informal governance strategies help project team members align their goals and objectives based on previous experiences. The measure to understand the level of collaborative project delivery practice followed and used in this study is purported in Table 3-2. The structured interview questions also use yes, or no responses to certain items. Additionally, the survey intends to capture the importance of each practice using a Likert score ranging from 1-Not important to 5-Very important.

The scores for *collaborative practices* are calculated based on the equation below:

$$\sum_{ij=0}^{n}(X1_{\ ij} + X2_{\ ij} + X3_{\ ij}) * 0.2 \ * \frac{100}{19\ (Total\ \#\ of\ Category\ responses)}$$

Whereby,

- $X1(Contractual\ related\ practice) =$ (1) Yes, or (0) No
- $X2\ (Procurement\ related\ practice) =$ (1) Yes, or (0) No
- $X3\ (Project\ related\ practice) =$ (1) Yes, or (0) No

Table 3-2: Full description of collaborative project delivery practices construct, metrics and measures used in this study (Chan et al., 2004; IPI, 2016; Mollaoglu & Sparkling, 2015).

Level of Collaborative Project Delivery Practices: Evaluation Method

	Yes	No	Not important=1 to Very important=5				
<u>Contractual Related Practices</u>							
Professional facilitator was used in this project.	☐	☐	1	2	3	4	5
A shared equity arrangement was indicated in contracts.	☐	☐	1	2	3	4	5
A partnering charter was used in this project.	☐	☐	1	2	3	4	5
A proactive conflict management tool that added structure to collaborative problem-solving processes was used in this project.	☐	☐	1	2	3	4	5
Equal power/empowerment was afforded to all project teams and team members in decision-making processes.	☐	☐	1	2	3	4	5
An incentive/fee/risk-reward/ or gainshare-painshare agreement was established in contracts.	☐	☐	1	2	3	4	5
<u>Procurement Related Practices</u>							
Parties were selected based on partnering experience.	☐	☐	1	2	3	4	5
We selected team members based on previous work experience with other team members.	☐	☐	1	2	3	4	5
Parties were selected based on technical expertise.	☐	☐	1	2	3	4	5
There was early involvement of key participants (e.g., designer/contractor/specialty subcontractors) during schematic design (SD).	☐	☐	1	2	3	4	5
	☐	☐	1	2	3	4	5
<u>Project Related Practices</u>							
Partnering workshops were held for this project.	☐	☐	1	2	3	4	5
Partnering scorecards were used in this project.	☐	☐	1	2	3	4	5
There were two or more project teams located together in a common office (i.e., colocation).	☐	☐	1	2	3	4	5
Partnering training/team-building sessions were held for this project.	☐	☐	1	2	3	4	5
Measurable and achievable milestones were established to determine the success of the project.	☐	☐	1	2	3	4	5
Project teams openly exchanged information across organizational boundaries (e.g., Building Integrated Modeling (BIM))	☐	☐	1	2	3	4	5
Quarterly partnering meetings were used in this project.	☐	☐	1	2	3	4	5
Monthly partnering meetings were used in this project.	☐	☐	1	2	3	4	5
Multi-tiered partnering was used in this project (i.e., executive, core team, stakeholders)	☐	☐	1	2	3	4	5
Specific task force used for conflict and issue resolutions	☐	☐	1	2	3	4	5

3.6.1.3 Goal Alignment Construct for Project Teams

This *goal alignment* measure is based on goals and objectives elicited in case study partnering charters, therefore, is specifically aligned with each case study project. For example, some projects included safety, schedule, budget, and submittals as goals in their partnering charters with well-defined performance metrics (sample case study partnering charter, goal aligning objectives, and performance metrics shown in Figure 3-2). Goals and objectives items identified in partnering charters were used to measure this construct using a five-point Likert scale (i.e., 1-strongly disagree to 5-strongly agree) to rate perceptions of individuals on their project-specific goals. This study collected partnering scores from case studies to indirectly investigate goal alignment.

PROJECT SCORECARD No. 1

GOALS / OBJECTIVES	ACTIONS / TIME FRAME	PERFORMANCE METRIC	SCORES* 1=L/5=H	COMMENTS (optional)
Safety	▪ Follow approved safety and traffic control plans and procedures ▪ Maintain a 5" safe path of travel at all times ▪ Keep site clean	✦ Zero accidents / injuries ✦ Excellent housekeeping	4.5 (5)	
Schedule	▪ Pro-active planning and sequencing of activities ▪ Submit detailed 4-Week Look Ahead Schedule weekly, include dates for inspections and notifications to public ▪ Update Critical Path and submit monthly	✦ Early completion ✦ Substantial Completion 7/21/17 ✦ Final Completion 8/26/17	4.0 (4)	
Budget	▪ Monitor Potential Change Orders (PCOs) closely and often; inform PM of PCO's ASAP ▪ Identify potential cost savings opportunities	✦ PCO's and CO's kept to a minimum ✦ Contingency not exceeded ✦ Cost savings documented	4.25 (4)	
Submittals: GI / Landscaping	▪ Maintain Submittal Log and report on status @ each Progress Meeting ▪ Submit all GI submittals for review and approval by July 15th	✦ Submittal process timely and well managed	3.9 (4)	Received from and responded to CM directly Some submittals are late and need to be expedited
Environmental Compliance	▪ Follow contractual requirements for environmental mitigation ▪ Cleanup continuously soil spills, track-out and debris; daily cleaning of parking lanes, streets and roads	✦ No non-compliance notifications ✦ Able to eat off the street	4.2 (4)	Exceptional job considering waste accumulated from residents
Green Infrastructure Quality	▪ Schedule coordination pre-activity meetings in advance of work ▪ Regularly hold comprehensive GI tailgates in the field ▪ Install GI materials without negative impacts	✦ No rework ✦ GI plans & specifications interpreted correctly and/or clarified & agreed upon	4.4 (5)	Only very minor rework, near perfect
Organization: Communication/Coordination	▪ Pro-active open and honest communication ▪ Issues clarified prior to writing RFI – visit site and discuss ▪ Timely notification of required coordination meetings SFWD-CDD	✦ Organization streamlined ✦ Responsive decision making	4.4 (5)	Great working relationship/trust/ open communication.
Community Appreciation	▪ Intent and value of project recognized ▪ No impacts made to driveways/ permanent pavement ▪ Minimal loss of parking due to construction work	✦ No complaints ✦ Timely notifications of scheduled work ✦ Project's progress documented regularly	4.7 (4)	
Team & Project Recognition	▪ Team members' roles and responsibilities respected ▪ All outstanding Field Issues addressed in a timely manner ▪ Pride in work accomplished	✦ Respect and trust exhibited by all Team members ✦ No issues raised above project level ✦ Project recognized for GI advanced work achievement	4.8 (5)	

1= Low / 5=High **Av. 4.3 (#responses)**

Figure 3-2: Sample Case Study Project Scorecard, Goal Aligning Actions, and Performance Metric

The scores for *goal alignment* are calculated based on the equation below:

$$\sum_{j=0}^{n}(X1_{j} + \cdots + XN_{j}) * 0.2 \ * \frac{100}{N\ (Total\ \#\ of\ scorecards\ )}$$

Whereby,

- $X1(Scorecard\ survey\ 1) =$ (1) Strongly disagree to (5) Strongly agree
- $XN\ (Scorecard\ survey\ N) =$ (1) Strongly disagree to (5) Strongly agree

3.6.1.4 Project Performance Construct

The *project performance* construct used in this study is developed from extant AEC literature. Project performance entails three first-order variables or elements from which measures are determined. The three elements are cost, schedule, and quality and safety performance. These also include owner satisfaction perceptions. Cost refers to outcomes regarding cost growth and additional expenses as a result of changes or other conditions during project delivery (Grajek, Gibson Jr., & Tucker, 2000; Gransberg et al., 1999; Yeung, Chan, Chan, & Li, 2007). Schedule refers to time performance such as being ahead or behind as compared to original contract completion dates (Grajek et al., 2000; Gransberg et al., 1999; Yeung et al., 2007). Quality and safety performance is concerned with the quality ratings, reducing the amount of wasted work or rework, and end-user satisfaction of the project. Meanwhile, safety performance is centered on accident rates (Yeung et al., 2007). This study investigates this construct using a five-point Likert scale (i.e., 1-not satisfied to 5-very satisfied), among other things, to rate perceptions of owners on their responses to questions within the survey. Table 3-3 describes the measures of the project performance used in this study.

Table 3-3: Full description of the project performance constructs, metrics and measures.

Cost Performance: Evaluation Method					
Cost Growth	☐ Contract Project Cost: $____________ ☐ Actual Project Cost: $____________ (Indicate if values are estimated)				
Total Cost of Partnering	Facilitator, meetings expenses, surveys, etc.: $____________				
Estimated Savings Due to use of Partnering	Cost Savings as a % of Project Budget: %____________				
Owner's Satisfaction with the Cost Performance of this project	**Not satisfied=1 to Very satisfied=5**				
	1	2	3	4	5

Schedule Performance: Evaluation Method						
						mm/dd/yy
	Planned Start Date (Starting from Planning):					
	Planned Completion Date:					
	Planned # of Work Days (Construction): ___________					
	Actual Start Date (Notice to Proceed):					
	Actual Completion Date (Substantial Completion):					
	Actual # of Work Days (Construction): _____________					
Owner's Satisfaction with the Schedule Performance of this project	**Not satisfied=1 to Very satisfied=5**					
	1	2	3	4	5	

Quality and Safety Performance: Evaluation Method						
Owner's Satisfaction with the Quality Performance of this project	**Not satisfied=1 to Very satisfied=5**					
	1	2	3	4	5	
Owner's Satisfaction with the Safety Performance of this project	**Not satisfied=1 to Very satisfied=5**					
	1	2	3	4	5	

Project performance scores are calculated using the following equation:

$$\sum_{ij=0}^{n} X1_{\,ij} * X2_{\,ij} * X3_{\,ij} * X3_{\,ij} \; * 0.2 \; * \frac{100}{4\,(Total\ \#\ of\ Category\ responses)}$$

Whereby,

- $X1(Cost\ performance) =$ (1) Strongly disagree to (5) Strongly agree
- $X2\ (Schedule\ performance) =$ (1) Strongly disagree to (5) Strongly agree
- $X3\ (Qualtiy\ performance) =$ (1) Strongly disagree to (5) Strongly agree
- $X4\ (Safety\ performance) =$ (1) Strongly disagree to (5) Strongly agree

Cost and schedule growth are objective metrics upon which construction projects are often compared (Touran, Gransberg, Molenaar, & Ghavamifar, 2011). These common metrics were used to report performance ratings based on project partnering documents from the six case studies. Cost and schedule growth performance ratings are computed using the following equations:

$$Cost\ Growth\ (\%) = \frac{(Actual\ Cost - Budgeted\ Cost)}{Actual\ Cost} * 100$$

$$Schedule\ Growth\ (\%) = \frac{(Actual\ Duration - Scheduled\ Duration)}{Actual\ Duration} * 100$$

Meanwhile, partnering facilitation cost as a percentage of the original project budgeted cost is calculated using the equation:

$$Partnering\ Cost\ (\%) = \frac{Partnering\ Cost}{Budgeted\ Cost} * 100$$

These computations are used to make objective comparisons across cases. A performance ranking is given to each case study project using the cost and schedule growth ratings. These rankings were similarly based on the aforementioned ratings.

3.6.2 Study Metrics for Quantitative Data

The following sections are used to describe the quantitative constructs and metrics intended for this study. The constructs are *goal alignment*, *transactive memory systems* (TMS), *individual/team performance*.

3.6.2.1 Goal Alignment Construct for Individuals

Goal alignment as a construct is measured by assessing the congruence among individuals working in AEC project teams. The process of collaboration and goal alignment across organizational boundaries involves learning curves in working as a team, bringing together varied skills, and investments in time and resources. Based on the literature, there are many collaborative practice elements used to align project teams such as the use of partnering workshops, establishing mutual goals and objectives, and involving key project stakeholders early in the design and construction project processes (Chan et al., 2004; Hughes et al., 2012a; Hughes et al., 2012b). This study uses a measure of goal alignment to investigate causality among coordinated efforts across organizational boundaries (Jap, 1999). The measure is based on reflective indicators shown in Table 3-4. This study investigates this construct using a five-point Likert scale (i.e., 1-strongly disagree to 5-strongly agree) to rate perceptions of individuals on their responses to questions within the survey.

Table 3-4: Full description of goal alignment construct and measures used in this study.

Goal Alignment: Evaluation Method (Multiple Choice: Likert Scale)
<u>Goal Alignment Mechanisms</u> (Chan et al., 2004; Jap, 1999)
Mutual goals and objectives in the partnering charter were communicated effectively.
Clear and compatible partnering goals were established by the project team.
I generally agreed with project-related goals established by the project team.
My attitude towards project-related goals established by the project team were similar.
My goals for the project were in close alignment with the project team.

3.6.2.2 Transactive Memory System Construct

A three-dimension scale is used to measure the second construct *transactive memory system*. The first order variables are specialization, credibility, and coordination with five items for each dimension (Lewis, 2003). TMS allows researchers to assess how well team members understand who possess specialized knowledge (specialization), how well they trust and rely on that knowledge (credibility), and the way this knowledge is efficiently organized (coordination). The widely adopted scale is used in team research to measure transactive memory systems (Lewis, 2004; Rau, 2005; Zhang, Hempel, Han, & Tjosvold, 2007; Zheng, 2012). The items in the scale capture responses using a five-point Likert scale ranging from 1 (strong agree) to 5 (strongly disagree). To measure TMS in this study the following variables shown in Table 3-5 are assessed (Lewis, 2003; Zhang, Cheng, & Fan, 2015).

Table 3-5: Full description of transactive memory system construct, metrics and measures used in this study (Lewis, 2003).

Transactive memory system: Evaluation Method (Multiple Choice: Likert Scale)
Coordination
The project team worked together in a well-coordinated fashion to complete the project.
The project team had very few misunderstandings about what to do during construction.
I believe we accomplished our task for the project smoothly and efficiently.
Credibility
I was comfortable accepting procedural suggestions from other team members
I trusted that other members' knowledge about the project was credible
I was confident relying on the information that other team members brought to the discussion
When other members gave information, I wanted to double-check it for myself. (reversed)
Specialization
I understand what skills my team members have and domains they are knowledgeable in.
The specialized knowledge of several different team members was needed to complete the project.
Overall, I am able to access other team member's thinking and knowledge.

In AEC project teams, specialization is an inherent property of project teams. For instance, owners, designers, contractors, and subcontractors come together knowingly bringing together their unique expertise to deliver projects. Specialization is one dimension that may not provide meaningful information in the context of AEC project teams, however, is still measured in this study.

3.6.2.3 Individual/Team Performance Construct

There are three dimensions that will be assessed in this study regarding *individual/ team performance* perceptions. Those are *project-related*, *communication-related*, and *team-related*. *Project-related* outcomes are investigated using common cost, schedule, quality and safety perceptions found in AEC literature (Grajek et al., 2000; Gransberg, Reynolds, & Boyd, 1997;

Yeung et al., 2007). These perceptions are used to assess how well project teams feel their performance was aligned with owner project goals. The second dimension, *communication*, is a measure of efficient information and knowledge sharing beneficial for team integration. The measure teases out efficiency, clarity, and frequency at which communication occurs within project teams (J. S.-C. Hsu, Shih, Chiang, & Liu, 2012).

Meanwhile, *team-related* refers to relational skills and attributes that are beneficial to the development of team communication, cohesion, and trust (Le-Hoai, Lee, & Son, 2010). Hoegl and Gemuenden (2001), purport several metrics to understand not only teamwork qualities but, individual and team performance. Based on their study, a reliable measure of *individual/team performance* is asserted consisting of several indicators. For example, the measure examines whether equitable decision-making, information sharing, and mutually beneficial outcomes were afforded to all project team members.

This study investigates these dimensions using a five-point Likert scale (i.e., 1-strongly agree to 5-strongly disagree) to rate perceptions of individuals on their responses to questions within the survey. Table 3-6 describes the measures of the individual/ team performance construct used in this study. Individual perceptions are aggregated to investigate sub-team performance outcomes. For instance, the owner, design, and construction team responses are aggregated forming sub-teams permitting inspections of variables at the team level of analysis.

Table 3-6: Individual/team performance construct, metrics and measures used in this study.

Individual/Team Performance: Evaluation Method (Multiple Choice: Likert Scale)
<u>Project Related</u> (Grajek et al., 2000; Gransberg et al. 1999; Yeung et al., 2007)
We adhered to cost goals for the project.
We adhered to schedule targets for the project.
We satisfied the scope of work for the project.
We accomplished our task for the project smoothly and efficiently.
We achieved project goals established by the project team.
We delivered a high-quality project for the owner.
There was little rework required in this project.
The project was delivered safely without major safety incidents.
<u>Communication Related</u> (Hsu et al., 2012)
There was efficient and effective information sharing among the project team (e.g., RFI responses).
There was frequent communication within the team.
Team members communicated often in spontaneous meetings, phone conversations, etc.
The team members largely communicated directly and personally with each other.
<u>Team Related</u> (Hoegl & Gemuenden, 2001)
All project team members were treated equally in the decision-making process.
All project team members worked with the same focus on project objectives.
We worked together to share information across organizational boundaries.
We worked towards mutually beneficial outcomes for all participants.
All project information was readily available to everyone involved in the project.
We always sought collective identification and resolution of problems.
Project team accountability was emphasized for all project outcomes.

Several of the measures in this study are underutilized in AEC literature, thus are assessed for adequacy as valid metrics using confirmatory factor analysis (CFA). This is covered in more detail in the analysis section.

3.7 Data Collection Procedure

Potential partnered-projects and teams are identified through collaboration with the International Partnering Institute. Researchers contacted project representatives via email communications and sent relevant information describing the research. Once key project representatives agreed to participate, follow communications were made to determine project characteristics (e.g., project size, duration, project delivery method, project type, etc.) and consistency with study goals. In advance of data collection, approved human subject protocols are implemented in this study established by the Institutional Review Board of Michigan State University.

The research documents and study data collection instruments are presented to the Institutional Review Board (IRB) at Michigan State University for approval. The documents include the survey instruments, structured interview questions, and other protocols required for human subject research. This study received an expedited approval due to its voluntary nature and maintains subjects' anonymity when clear identifiers are requested from study participants.

A pilot survey of the intended population was used to test the survey instrument. A survey provides quantitative information depicting attitudes and opinions of the population under consideration. Survey data is collected via partnered construction projects that are completed or nearing completion. Obtaining field level data places the investigated phenomena into the real context where implications can be understood and accessed (Yin, 2003). The rationale is to gain information specifically emanating from participants involved in the partnering process, although no field manipulations or experiments are undertaken in this pilot study.

The final survey instruments and metrics are revised based on feedback from industry professionals and academics. To understand the extent to which collaborative project practices affects goal alignment and subsequently performance outcomes, several project teams are sampled from a database of construction projects across the U.S. working under partnered-project arrangements.

3.7.1 Qualitative Data Collection

In addition to survey data, project/team level data are collected via collaboration with key partnering team members and partnering facilitators. Structured interviews are conducted with key representatives of the owners' team to understand project performance outcomes using a survey questionnaire (Appendix B). The project documents include partnering charters, partnering scorecards, partnering session documents, and project meeting minutes. To access the information, a web-based file sharing platform is established to allow the researcher to collect project data. The information sharing is managed by the key project team members (i.e., owner's representatives, partnering facilitator, construction manager team).

3.7.2 Quantitative Data Collection

Requests to participate in the survey are sent to key project team members (e.g., owner representatives, construction project managers) using email and monitored by researchers. Researchers are included on all correspondences to monitor potential respondents and for follow-up. An online survey system is used to administer and collect survey data. Follow-up is provided to project participants identified by key project team members and includes a link to the online survey. The survey instrument consists of three major components to assess team dynamics and outcomes based on current perceptions of individuals' during collaborative project delivery (Appendix A). Self-reporting components in the survey are used to infer the existence of transactive memory systems and capture performance outcomes. According to Lewis and Herndon (2011), indirect measures using indicators are most appropriate to predict the existence of TMS or its effects. This is especially important in settings where observing or direct measuring is not practical or feasible.

3.8 Qualitative Data Analysis Methods

As previously mentioned, a mixed-methods research approach is followed in this study. There are two levels of analyses pertinent to this study, individual-level and project level. According to Yin (2003), multiple units of analysis offers greater flexibility to inspect data for consistent patterns across units and cases. Moreover, mixed-methods enables researchers to use two or more types of data collection methods and data analysis methods (i.e., quantitative, qualitative). These data are used to integrate findings, draw inferences within a single study or theoretical perspective, and triangulate findings from multiple forms of data (Campbell & Fiske, 1959; Miller et al., 2011). The section discusses qualitative data analysis methods while section 3.9 covers quantitative data analysis methods.

This stage of the mixed-methods approach is to understand qualitative evidence resulting from the case studies. The project level data are collected using a qualitative approach. Project-specific data is comprised of evidence such as collaborative project delivery practices (e.g., use of partnering charters, scorecards, workshops) and project risk factors (e.g., cost/schedule impacts, partnering team experience, complexity, etc.). Meanwhile, project team rosters are collected from main project participants (e.g., partnering facilitator, owner representative, or Construction Manager/General Contractor (CM/GC) project manager).

Structured interviews are performed to collect data from key stakeholders representing the owner team (e.g., owner, owner representative, or other key stakeholder involved in project delivery) regarding project performance outcomes (e.g., cost, schedule, quality, and conflict resolution). These project-level data are analyzed in parallel with survey data using pattern-matching, content analysis, and cross-case synthesis to help integrate findings. Meanwhile, project risk factors and collaborative project delivery practices are objectively scored during structured interviews. These data are also qualitatively analyzed for links with other variables. Before delving into the case study data analysis and model validation, reliability and validity are discussed.

3.8.1 Data Quality in Case Studies

There are effective case study tactics available to ensure validity and reliability criteria are satisfied. In case studies, the researcher is concerned with four design tests being construct validity, internal validity, external validity, and reliability. The four tests, case study tactics, and phase of research in which the tactic occurs, in parentheses (), are described below (Yin, 2003):

<u>Construct validity:</u> Correctly operationalizing measures for the concepts under investigation; Important to specify changes that are to be studied and demonstrate how measures of these changes adequately reflect specific types of changes selected.

- Use multiple sources of evidence (data collection)
- Establish a clear chain of evidence (data collection)

- Solicit key informants to review draft of the case study report (composition)

Internal validity: Establishes a causal relationship in explanatory case studies where certain conditions are shown to lead to other conditions and are not spuriously related.

- Do pattern-matching (data analysis)
- Do explanation-building (data analysis)
- Address rival explanations (data analysis)
- Use logic models (data analysis)
- Use cross-case synthesis (data analysis)

External validity: Establishes the domain where findings can be generalized.

- Use theory in single-case studies (research design)
- Use replication logic in multiple-case studies (research design)

Reliability: Demonstrates that proper operations of a study can be replicated with the same results.

- Use case study protocol (data collection)
- Develop a case study database (data collection)

This study adopts these tactics to satisfy the research quality criteria in order to benefit from the richness found in case studies. Well-done theory building from multiple-case studies, similar to experiments, can be very objective and allow formal analytical modeling (Eisenhardt & Graebner, 2007).

In this study, the researcher used six case studies to establish a clear chain of evidence. The data collected from case studies were compiled into a database for further inspection and analyses. Structured interviews with key stakeholders (i.e., owner/owner representative and contractor) are recorded with participates consent to aid in transcriptions. The transcriptions and a summarized version of the researchers' observations are provided to the interviewee's for validation. These observations are used to give a recapitulation for each case study, analyze data using pattern-matching, and to provide findings from cross-case synthesis.

3.8.2 Case Study Data Analysis

Using single and multiple-case studies in theory building to establish propositions, theoretical constructs, and provide empirical evidence continues as a valid and rich research strategy (Eisenhardt & Graebner, 2007). Despite the advantages, Eisenhardt and Graebner (2007) contend challenges abound as to why inductive theory building rather than theory testing is required to understand the specific phenomenon. In response, emerging and competing theories are generally better understood by placing the phenomenon in its context, especially regarding complex social processes addressing "how" or "why" research questions. Based on this, a multiple case study approach is followed in this study.

According to Yin, (2003), there are two general analytic strategies used in case study analyses. The first is to rely on theoretical propositions as a guide which forms the research design of the case study. The propositions also help direct the analysis to specific data so other superfluous information can be ignored. For example, many other things take place during partnered-project delivery which can be tracked such as achieving certain project schedule milestones. This information, though important, is irrelevant to the goals of this study. The second strategy is to develop a case description or framework for organizing the case study. This should include the general characteristics and relationships that existing within the phenomenon. Both of these strategies can be achieved by using pattern-matching, explanation-building, or time-series analysis (Yin, 2003).

Pattern-Matching

Pattern-matching is a case study technique used to compare empirically based patterns with predicted ones. When doing pattern-matching the aim is to inspect the data for expected outcomes (i.e., predicted results found and alternative patterns absent), rival explanations (i.e., the presence of certain explanations should exclude the presence of others), or simpler patterns (i.e., pattern-matching is valid with only a few variables or clear differences among derived patterns).

Explanation Building

Meanwhile, explanation-building is an iterative process of analyzing case study data to identify causal links. The process begins with initial theoretical statements, then, findings of the cases are compared. The statements are revised, if needed, and compared against details in the case.

This is followed by additional revisions when required to assure specific propositions are analyzed, then, compared with the other cases. Yin (2003) cautions against this technique as the analyses may shift from the original topic under investigation. Time-series analysis is commonly employed to address “how” and “why” questions in regards to relationships or events that change over time. With this type of case study analysis, the researcher attempts to identify theoretically proposed sequences of events believed to lead to specific outcomes. The events must be explicitly identified by the researcher prior to the investigation. From this, comparisons can be made between the trends in the data with those of empirically derived data points.

Cross-Case Synthesis

The purpose of cross-case synthesis is to identify common patterns among data which provides internal validity. An objective scoring or comparison criteria is established to facilitate comparisons across multiple case studies. Content analyses are conducted among objective data for similarities and/or differences in the features of each case study.

3.1 Quantitative Survey Data Analysis Methods

Quantitative data resulting from this study are analyzed using two distinct approaches which are reviewed in this section. A description of factor analysis is given first. Factor structure analysis is used to ensure the data is representative of constructs asserted in this study. Next, confirmatory factor analysis, a model validation technique, is discussed. This technique is used to examine if the model is consistent with the data. Multivariate regression correlation analysis (MRC) is described following model validation. MRC is used to analyze multiple variables present in statistical models. MRC permits testing relationships among independent and dependent variables while remaining more flexible than analysis of variance (ANOVA) and analysis of covariance (ANCOVA) (Cohen, Cohen, West, & Aiken, 2013). Before discussing data analysis procedures, reliability and validity are addressed.

3.1.1 Data Quality for Survey Measures

There are several tactics available to the researcher to address reliability and validity during data collection. The strategies from which one can choose varies and depends on how data is captured in the study (i.e., survey instrument, observations, ethnography, etc.). This study uses a mixed-methods approach to collect both empirical evidence and case study data, thus are discussed separately. Section 3.9.1 deals with case study data reliability and validity concerns.

<u>Strategies for Survey Measurements</u>

Reliability is primarily concerned with the consistency of items within a measure and stability of the measure over time. Several methods are available to assess the stability of a measure such as test-retest, alternate forms, and split-half test (Nunnally, 1978). These methods are able to determine the reliability coefficient (i.e., alpha) during conditions of transient, content, random response, and rater error. The internal consistency of a measure is generally associated with interrater reliability. Homogeneity of the sample and test length can affect the variation within rater responses and, therefore, true score and observed score variance. Spearman-Brown prophecy is one such method to evaluate internal consistency and the appropriate test length.

A valid measure is the notion that we are measuring that which is intended (Nunnally, 1978). To inspect the validity of a measure, a multi-trait multi-method (MTMM) procedure or factor analysis (FA) can be followed (Shaffer, DeGeest, & Li, 2016). The MTMM procedure will help partition the responses and variance according to shared method variance, shared trait variance, and other combinations based on a matrix. Perhaps, the measure is encapsulating multiple dimensions that were thought to be unidimensional. This can also be seen in a factor analysis. In factor analysis, responses are inspected to determine the amount of variance based on how it loads onto a single factor and its items. From this, a factor structure emerges which can serve as an indication of dimensionality.

3.1.2 Model Validation using Confirmatory Factor Analysis

The data from individual team members are aggregated to represent information investigated at the team level. Inter-team-agreement can be assessed by calculating intraclass correlation coefficients (James, Demaree, & Wolf, 1984). This method is applied as justification for aggregating individual scores into team-level scores, therefore providing inter-rater reliability.

The constructs investigated in this study are measured using measurement models which have underlying indicators or factors. For example, TMS has three dimensions with five indicators measuring each dimension. Measurement validity can be assessed in this instance as there are five parameters to estimate and 10 correlations that can be employed to generate estimates. These estimates are used to assess the fit of the model. The internal consistency theorem is used to examine the resulting correlation matrices. This analysis allows the researcher to inspect predicted and obtained inter-item correlations and subsequently the validity of the measurement (Hunter, Gerbing, & Boster, 1982).

Confirmatory factory analysis (CFA) is explored to assess whether a model fits the data. This method allows one to analyze the data against various goodness-of-fit indices [e.g., comparative fit index (CFI), root mean square error of approximation (RMSEA)]. The application of CFA is also used in convergent and discriminant validity analysis. Results from these analyses validate whether the hypothesized model is consistent with the data to which assertions can be made and discussed.

Structural equation modeling (SEM) is used to test the hypothesized model in this study (Figure 3-3). In the model X represents goal alignment, M is transactive memory system, and Y is individual/team performance. The model asserts the three parameters that are available for estimation to test the hypothesized model.

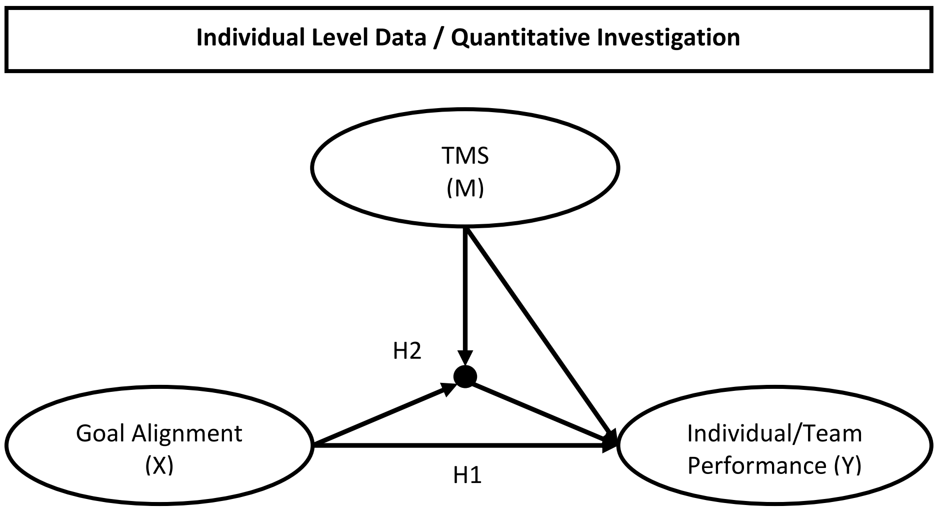


Figure 3-3: The Relationship and Hypotheses between Goal alignment, Transactive Memory Systems, and Individual/Team performance

The above parameters are estimated by their correlation coefficients according to ordinary least squared estimation (OLS). These predicted correlations are analyzed against obtained correlations and used to determine if the model is consistent with the data. From this analysis, MRC analysis using multilevel modeling strategies can be explored.

3.1.3 Statistical Analysis using Multilevel Modeling

Multilevel data is oftentimes used in the field of psychology research to investigate personality, social and organizational behavior. Other uses for multilevel modeling are education and educational policy, communication research, and sociology. Essentially, its practicality applies to any situation in which the data are hierarchical in nature with both macro and micro level phenomena (Nezlek, 2008; Snijders & Bosker, 2012). As an example, in studies involving individual pupils in classrooms, the data is comprised of several units of analysis. In this example, level one would be representative of pupils, level two being classrooms or schools. Typically the levels are reflective of the hierarchy in which the sample is selected from a larger population. Multilevel modeling is also applicable to longitudinal data or study comparisons in meta-analysis research (Hox, 2010).

There are several distinct advantages of multilevel modeling over ordinary least squared (OLS) regression. In multilevel modeling, disaggregated data are available to accurately investigate from any level, whereas in OLS the assumptions of independent observations are violated resulting in unfounded conclusions (Snijders & Bosker, 2012). Moreover, multilevel modeling permits a model in which dependent variables are at the lowest level and explanatory variables are defined at any level including aggregation of level one variables. Figure 3-4 is shown to demonstrate the modeling levels in order to study organizations (i.e., Level 1) and construction projects (i.e., Level 2). Based on the figure, organizational units are clusters of interorganizational project teams nested within construction project units. The complex interplay between characteristics of the two units can be analyzed via a multilevel model. Thus, the structural dependence explaining within- and between-group variance are efficiently elicited.

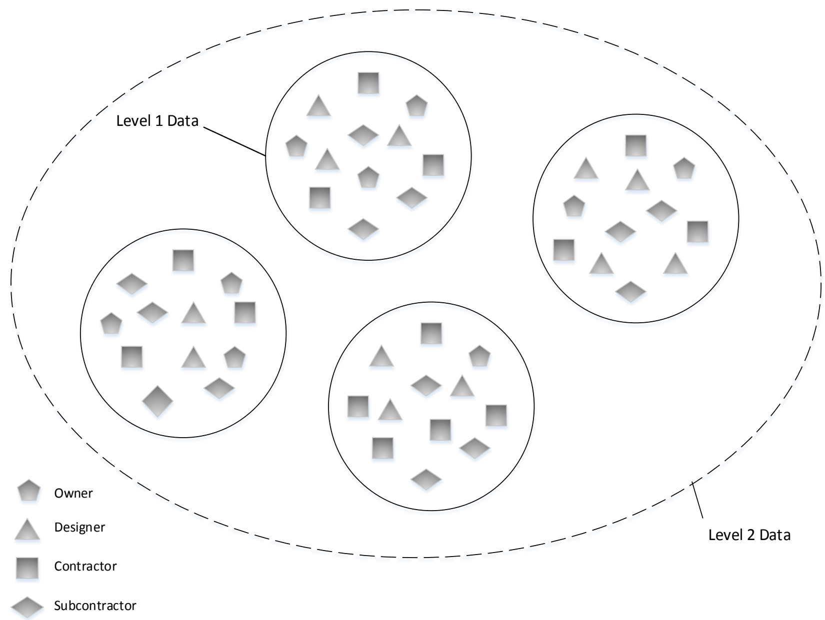


Figure 3-4: Multilevel sample selected at random from population

According to Snijders and Bosker (2012), care must be taken to avoid three areas of potential errors when working with multilevel models and data aggregation. An error can occur when a "shift of meaning" is accidentally inferred. For instance, a variable that is aggregated to level 2 (e.g., team cohesive ratings) used as a metric for team performance are not reflective of organizations' attributes or level 1 units. This idea of aggregation and disaggregation is reflective of how variables are constructed. When lower level variables are aggregated as the mean of a group, it is interpreted as a structural variable (Hox, 2010). The mean structural variables are, then, used as the explanatory variable at higher levels of analysis. Alternatively, contextual variables are disaggregated in that they receive the group mean to which they belong at the higher level of analysis (Hox, 2010). A second well-known source of error is related to ecological fallacies. An ecological fallacy occurs when one falsely asserts correlations between macro-level (i.e., level 2) variables which are then used as substitutions for micro-level (i.e., level one) variables (Robinson, 1950). As an example, Robinson (1950) belied that researchers were tacitly abusing macro-level data connecting race to illiteracy as explanatory for same variables at the micro-level of analysis. The third potential error source is that of disregarding the original data structure (Snijders & Bosker, 2012). A concern is with data aggregation which is used to derive our within-group and between-group regression lines. When the data structure is not firmly considered or understood, misleading interpretations can occur. Knowing this, multilevel modeling is efficient in handling disaggregated data, and as a result, allows researchers to investigate cross-level interaction effects.

The use of random coefficient models is best when 1) the groups are believed to be unique categories from which conclusions will be made specific to the categories; 2) the groups are asserted as a sample representative of a larger population (i.e., real or hypothetical) and conclusions are made by the researcher regarding this population; 3) testing the effects of group-level variables to understand the "unexplained" between-group variability; and, 4) dealing with small group sizes (i.e., 2-100) which assumes independent and identical distributed group effects (Snijders & Bosker, 2012). In satisfying the conditions above, this study implores the benefits of a random effects model. The data structure and a basic multilevel model are presented next.

In this study, the researcher examines two-level data represented by AEC project teams (i.e., macro-level) and individuals (i.e., micro-level). One basic multilevel model underlying this data structure is described by the following random effects equation:

$$Y_{ij} = \beta_{0j} + \beta_{1j}X_{ij} + \beta_{2j}M_{ij} + \beta_{3j}X_{ij}M_{ij} + e_{ij}$$

Or, $(Individual/Team\ Performance[IP])_{ij} = \beta_{0j} +$

$\beta_{1j}(Individidual\ Goal\ Alignment\ [IGA]) + \beta_{2j}(Individual\ TMS\ [ITMS]) +$

$\beta_{3j}(IGA * ITMS) + e_{ij}$

In the model above, there is 'i' level 1 observations nested within 'j' level 2 units of a continuous variable Y. These are modeled as a function of the intercept for each level 2 unit (β_{0j} or average $individual\ performance$ in group j), error (e_{ij}), and the variance of (e_{ij}) is the level 1 random variance. The regression coefficient for X is β_{1j} (i.e., average effect of *goal alignment* in group j) and similarly, the regression coefficient for M is β_{2j} (i.e., average effect of *TMS* in group j). The interaction effect has a regression coefficient for XM given by β_{3j} (i.e., average effect of interaction between *goal alignment* and *TMS* in group j). The random and fixed slope intercepts for the above are given by:

$\beta_{0j} = \gamma_{00} + \gamma_{01}(Mean\ Team\ GA\ [SGA])_j + \gamma_{02}(Mean\ Team\ TMS\ [STMS])_j$

$\beta_{1j} = \gamma_{10} + u_{1j}$

$\beta_{2j} = \gamma_{20} + u_{2j}$

$\beta_{3j} = \gamma_{30} + u_{3j}$

The full model, when rewritten, is given as:

$Individual/Team\ Performance = \gamma_{00} + \gamma_{01}(Mean\ SGA)_j + \gamma_{02}(Mean\ STMS)_j +$

$\gamma_{10}(Individual\ GA)_{ij} + \gamma_{20}(Individual\ TMS)_{ij} + \gamma_{30}(IGA * ITMS)_{ij} + u_{1j}\ (IGA) +$

$u_{2j}\ (ITMS) + u_{3j}\ (IGA * ITMS) + e_{ij}$

The full model above is used for analyses at the individual-level while controlling for the sub-team level. The individual model above asserts individuals are nested within sub-teams. Moreover, the effects of individual *goal alignment* and individual *TMS* are expected to vary randomly with *individual performance*. The model also includes the mean effects of sub-team *goal alignment* and team *TMS* or within team effects on individuals. In the model above, the effects of sub-team goal alignment and sub-team *TMS* on sub-team performance is fixed across projects.

3.2 Summary

This chapter postulates a clear methodology to which this study follows in addressing the research needs. The objective of this study is to better understand the relationships between project risk factors, collaborative project delivery practices, goal alignment, transactive memory systems (TMS), and performance outcomes in interorganizational AEC project teams. These objectives are achieved by following a research process as described in this chapter. The research process entails the selection of an appropriate research strategy, developing study metrics, and establishing data collection procedures. This chapter finishes with the procedures for both quantitative and qualitative data analyses. Based on the structure of the data, multilevel modeling techniques are described in detail as well-suited for this study along with case study analysis. Meanwhile, the chapter discusses factor analysis techniques used to understand the factor structure of constructs, along with, how these approaches are used in model validation.

CHAPTER 4 QUALITATIVE ANALYSIS

This chapter gives the results from case study project documents and structured interview data used in qualitative analyses. In all, six case study projects and their teams were investigated to understand the relationships between *project risk factors*, *collaborative project delivery practices*, *goal alignment*, and *performance outcomes*. It begins with a brief description and summary of each case study in section 4.1. Then, pattern-matching and cross-case analyses are presented in sections 4.2 and 4.3 to summarize study findings.

4.1 Summary of Case Study Projects

The following sections offer a brief introduction to each case study investigated in this study. Six case studies were investigated varying in size, duration, and project types. The researcher conducted structured interviews with two individuals from each case study project, representing both the owner and contractors. Project details were gathered from project documents, correspondence with project participants during structured interviews, and the facilitators from each case study.

4.1.1 Case Study Project #1

This project involved installation and green infrastructure improvements associated with a storm sewer system. The project, located within a local community, was part of a multibillion-dollar citywide Sewer System Improvement Program (SSIP). Several unique green features were incorporated in the project. For example, permeable pavement systems and rain gardens were installed to effectuate natural soil filtration processes. The goals included improvements to residential streets, more pedestrian and bike-friendly corridors, and green spaces. In addition, the City wanted to reduce stormwater runoff and its impact on the sewer system. The budget cost for the project was $5.59 million while the scheduled work duration was 375 workdays.

The stormwater management system is designed to accommodate 950,000 gallons of stormwater each year. In addition, the project comprised two acres of impervious surface that were improved. The green features accounted for 18,444 square feet of permeable pavement/concrete and 2,250 square feet of rain garden. The project infrastructure encompassed eight city blocks in a major metropolitan city. The scope of the project was increased during construction to include stormwater infrastructure and surface replacements for two additional city blocks.

The project followed a traditional DBB project delivery approach and included a formal partnering process. Partnering was institutionalized in project documents and requirements including the use of a neutral third-party partnering facilitator. The partnering structure for the project is described next.

Partnering facilitation services for the project included the development of an informal partnering charter, a partnering kick-off session, three partnering workshops, performance monitoring via scorecards, partnering meeting minutes, an issue resolution ladder, and action plans to reconcile issues. The project team identified nine goal-aligning objectives for the project as shown in Table 4-1. The project charter also included specific action items and responsible leads for each of the primary goals.

Table 4-1: Case Study #1 Project Charter Goals and Performance Metrics

Goal-aligning Objectives	Performance Metrics
Safety	Zero accidents Excellent housekeeping
Schedule	Early completion Substantial completion by 3/8/17 Final completion by 5/18/17
Budget	Potential Change Orders and Change Orders minimized Contingency not exceeded Cost savings documented
Submittals	Submittal process timely and well-managed
Environmental Compliance	No non-compliance notifications Focused on cleanliness
Green Infrastructure Quality	No rework Green Infrastructure (GI) supplier plans and specs clearly defined
Communication/Coordination	Organization streamlined Responsive decision-making process
Community Appreciation	No community complaints Timely notifications of scheduled work Project's progress documented and communicated regularly
Team and Project Recognition	Respect and trust for all team members No issues escalated above field project team Project recognized for GI advanced work achievements

A decision-making and issue resolution ladder were also utilized in this case study project. There were four levels and associated FAST teams designated at each level. Those were Field level, Project level, Program level, and Executive level ordered from lowest to highest. Additionally, it included time escalation triggers (e.g., one day, up to one week, etc.) and a process to drive the decisions (e.g., discuss onsite ASAP, document in meeting minutes, email, and conference call). The project team can also instigate objective mediation from the partnering facilitator to help resolve issues.

Comments from Case Study #1 Survey Respondents

- "Team integration on this project was definitely enhanced through the partnering process. It was a pleasure working with everyone involved, and the results speak for themselves. The project was completed on time, within budget and with high quality."
- "All team members were willing to make adjustments to reach successful project completion. Communication was excellent. The contractor and all team members provided a finished product of the highest quality."

4.1.2 Case Study Project #2

This case study project encompassed an 18.4-mile long in-service water tunnel repair. The water tunnel serves a large population and many stakeholders (e.g., Public Utilities) which made it critical to complete the work efficiently. The water system required a complete shutdown for extended periods of time making it even more important to get buy-in from multiple-stakeholders and project participants.

The project consisted of thorough pre-inspections of the water tunnel system, lining repairs and complete replacements, rock coring to improve the tunnel system, and numerous safety precautions. Due to the extreme safety conditions imposed on workers, safety was the number one priority on the project. Therefore, extensive precautions were in place such as having specific safety personnel and rescue teams dedicated to the project, frequent safety audits, along with ventilation systems and monitoring throughout the entire tunnel span. Safety concerns ultimately ended up becoming part of the partnering charter.

The budgeted cost for the project was $4.96 million and was scheduled for completion in 255 workdays. The case study project was delivered using a DBB project delivery approach and included partnering as a tool to help the project achieve its goals. A neutral third-party facilitator was used in the project. An informal partnering charter was developed and followed by the project team. In addition, facilitation services for the team included three partnering workshops, scorecards, partnering meeting minutes, an issue resolution ladder, and decision focused action plans.

The goals of the project primarily revolved around safety, schedule, contract documentation, and clear communication amongst the teams. Eight goals shown in Table 4-2 were identified by the project team and served as goal-aligning objectives.

Table 4-2: Case Study #2 Project Charter Goals and Performance Metrics

Goal-aligning Objectives	Performance Metrics
Shutdown Management	Achieve completion milestone dates as required
Safety and Health	No injuries or accidents No lost or forgotten personnel left during shifts No environmental health issues during work (e.g., air, water, etc.)
Schedule	Shutdown completed by 2/27/17 @ 5:00 PM PST
Contract Documentation	No outstanding change orders
Communication/Coordination	No communication/coordination misunderstandings
Field Issues	No issues raised above Project Leadership level identified on issue resolution ladder except unforeseen conditions
Quality	No wasted work or rework
Integrated Team Responses	Exceptional teamwork achieved

The project team established five different levels of decision-making in their issue resolution ladder. Those five levels from lowest to highest were Field leadership, Site leadership, Project leadership, Program leadership, and Executive leadership. The Program level includes other project team members such a Senior Program Manager from the Public Utilities

Commission. A Dispute Resolution Advisor was also identified as part of the issue resolution procedures. This individual can be engaged informally by the project team at any level to help facilitate the decision-making process. The issue resolution ladder included key triggers for escalation and decision-making processes to resolve each issue at the lowest level possible.

Comments from Case Study #2 Survey Respondents

- “This project would have been in claims if we had not used formal partnering.
- Many team members were brought on after the start of the project, thus expectations and integration into the team were problematic. Staffing needs to be finalized before the start, allowing for integration, roles and expectations to be fully addressed.”
- “Check Locally Based Enterprise (LBE) qualifications prior to approval of them as subcontractors under the prime contractor. This lack of qualifications led to many disagreements on the project.”
- “I feel that it is important to get the project team thinking as a "we" in lieu of a "you and I" situation. I feel that by doing this everyone is working to complete the project and there are fewer areas for arguments which slows down the project.”
- “This was an extremely critical project for the ratepayers and the Public Utility. Everyone involved with the project understood the importance and worked together as a team.”

4.1.3 Case Study Project #3

This case study project involved an estimated $165 million investment into removal and repairs to a major interstate highway and 13 associated bridges along a busy metropolitan community.

This ongoing project has a scheduled duration of 595 workdays for completion. The construction work included removing and replacing concrete surfaces and bridges that also support drainage systems, along with paving and patching. A unique feature of this case study was the replacement of a 49-year-old, 1.63-mile long bridge span which carries 37 million vehicles per year. As a result, complex demolition procedures were required and had to be reviewed well in advance of construction. Intelligent transportation equipment systems were also installed as part of the project. Some elements of the intelligent transportation system were electronic signage, cameras, and traffic monitoring systems which allow the Department of Transportation (DOT) to communicate travel times, accidents, and other mobility issues with drivers.

Due to its proximity to oil refineries, railroads, residential communities, and utility infrastructure systems, the project team identified and frequently discussed project risks. Attention was directed towards Maintenance of Traffic (MOT) and safety of all individuals whether working onsite or traveling the surrounding areas. Some unforeseen project risks uncovered during construction were inferior steel decks which needed to be replaced along with some structural steel elements. These added change order cost and scope to the project. Meanwhile, the project team had to factor winter conditions into the construction duration and processes.

The project delivery approach in this case study was DBB and incorporated partnering into its project requirements. The team used a neutral third-partnering facilitation service to help develop a formal partnering charter, facilitate partnering workshops, provide partnering meeting minutes, and administer performance surveys to monitor the project teams' goals and objectives. The partnering facilitator also used team building exercises to help establish trust and shared objectives within the project team. Quarterly partnering workshops were held on the project with the team having completed nine, thus far. The project team also leveraged an issue resolution ladder with four levels of decision-making teams and defined escalation times (i.e., Level 1 Field: Immediate, Level 2 Project: ½ day, Level 3 Program: 1 day, and Level 4 Executive: 2 days). The formal partnering charter and mission statement captured mutual goals and objectives for the project stakeholders. This document was solidified with signatures from all the respective parties.

Table 4-3 illustrates the goals and performance metrics which the project team followed in this case study. In all, 12 key goals were identified by the project team to which they revisited and evaluated during partnering progress meetings. Not only did the team include project goals but encouraged organizational opportunities for contractors and subcontractors.

Table 4-3: Case Study #3 Project Charter Goals and Performance Metrics

Goal-aligning Objectives	Performance Metrics
Safety and Security	Delivered safe and secure working environment for all stakeholders
Schedule	Meet project schedule and milestone dates
Budget	Complete project on budget
Timely Decision-Making	Make timely decisions to avoid delaying work
Opportunity to Profit	Contractor/Subcontractors afforded fair profit opportunity
Environment	No environmental impacts
Quality	No wasted work or rework; Installed for longevity
Risk Management	Anticipate risks and collaboratively address all emerging issues
Seizing Opportunities	Always seek project improvements at every stage
Team Respect and Community	Respect for team and concerns of all stakeholders including community
Pride and Fun	Make project a fun process and maintain pride for the finished project
Open Relationship with FHWA	Open communications/working relationship to drive timely issue resolution
Focus on Project First	Empowered team focused on project goals

Comments from Case Study #3 Survey Respondents

- "I found that when we would meet to resolve issues we got better results when the number of attendees was lower. With the large group settings and many specialists in the room, issues tended to drag on and usually required a second meeting to resolve."
- "Across the teams - both Contractor and Owner - there remained a few personality traits that I believe contributed to not allowing for a fully open and honest communication experience which in turn tends to hurt the partnering process. Overall was ok."
- "I was only focused on worker safety, for both the owner and the contractors. I was glad to see that safety was well regarded by both."

4.1.4 Case Study Project #4

This partnering case study project entailed complete demolition and replacement of a major metropolitan bridge with two new bridges to handle both eastbound and westbound traffic. This historic bridge dates back to the 1950s and has been in operation for close to 60 years in the U.S. The project was surrounded by three railroad systems, a river, residential communities, existing businesses, supported approximately 20 public utility systems, and served as a major traffic corridor to downtown events. The project was part of a larger state infrastructure investment focused on improving safety, reducing traffic congestion and delays, and modernization objectives for the interstate system.

As with many roadway and bridge projects, MOT and safety are of great concern to the project team. As such, the team followed careful planning and preparation strategies for bridge demolition especially considering the required use of explosives. Other project risks involved in the project were construction work 115 feet above active railroad systems and 136 feet above a major shipping corridor along the river below. Poor soil conditions were also identified early-on by the project team which required additional shoring systems.

This $272.99 million joint venture (JV) project was delivered using a DB project delivery approach. The planned schedule duration for this project was 1,303 workdays. The project is in its final stage of completion with minor finishing activities remaining (e.g., painting). Partnering is institutionalized in construction contracts within this state DOT. In addition, this state DOT has embraced best-value DB project delivery across this and many other projects despite being publicly funded projects.

A formal partnering process and charter were developed in this project. A neutral third-party facilitator worked with the project team to develop its partnering charter, partnering mission statement, lead partnering workshops held quarterly and tracked partnering health using scorecards. Team building exercises were incorporated into partnering workshops to effectuate trust and goal-alignment amongst the project team. The facilitator also provided partnering meeting minutes and helped the team establish an issue resolution ladder.

The issue resolution ladder, in this case study, was comprised of four decision-making levels being Field level, Project level, District level, and Executive level. The project team also had access to a Dispute Resolution Board (DRB) to help resolve issues objectively. Each level included an agreed upon escalation time ranging from one day to 14 days maximum. The partnered-project team put forward sixteen varied goals and objectives for the project. The focus ranged from project-specific goal aligning items such as safety for the public and project participants and budget cost and schedule goals to broader community objectives. In particular, the project team wanted to ensure the local contracting community participation and Disadvantaged Business Enterprises (DBE) programs would be strengthened as part of this investment. Table 4-4 below describes the goal-aligning objectives for the project and strategies to monitor progress. Goals were codified to the project with signatures from representative stakeholders from each organization involved in the project.

Table 4-4: Case Study #4 Project Charter Goals and Performance Metrics

Goal-aligning Objectives	Performance Metrics
Safety	100% commitment to safety for workforce and public
Quality	Construct project to last and serve public interest
Cost and Schedule	Complete project on budget and schedule
Environment	Respect for environment
Issue Resolution	Respectfully, timely, without DRB involvement and no litigations
Decision-Making	Resolve issues and decisions at lowest level possible
Partnership	Partner and maintain relationships with all stakeholder (e.g., project, public, local government, railroads, permitting agencies)
Relationships	Trust and respect all project stakeholders
Focus on Project First	Attitudes of success and fairness with focus on project first
Risk Management	Anticipate issues and mitigate risks early with clear plans in place
Quality Management	Leverage independent quality management to ensure project exceeds design life
Communication	Open and effective communications
Team Empowerment	Empowered team focused on project goals
Recognition	Strive for award-worthy quality, aesthetics, and partnering
Community Involvement	Grow Disadvantaged Business Enterprise (DBE) program and local contractor participation
Traffic Maintenance	Effectively manage maintenance of traffic issues

Comments from Case Study #4 Survey Respondents

- “This project went very well except for the final painting. The responses to this survey are based on the project as a whole. The negative responses are reflective of the issues with painting the bridge.”

- “Overall this project had a great teamwork environment. The mutual respect was evident. There have been challenges in painting the bridge, but hopefully, those issues will not overshadow an otherwise successful project.”
- “All Parties (Owner, Contractor, and Design-build Team (DBT)) need to totally buy-in to partnering. One person not committed to it will sink the entire effort. Both parties need to make sure there is no "side tally" sheet tracking which side got what they asked for.”
- “I worked as the Public Communication consultant - not an everyday roll in most projects. My responsibilities meant working with the owner, contractor, designer and Independent Quality Firm - all of which I found put the project's best interest first.”
- “Team integration also needs reminding of their responsibilities for each of the required roles.”
- “Specifically, Designers, Constructors, Quality Control (QC), Quality Assurance (QA), and Quality Oversight (QO). Too much overlap, especially between the QC, QA, and QO create inefficiencies.”
- “The team functioned well together on almost all issues. The painting issue was challenging and seemed to be handled differently regarding collaboration and open communication.”
- “Because of the pace/nature of work, most communications/information is shared electronically. It is very important to have information technology (IT) involved throughout the project duration to ensure the output from various software used is transmitted seamlessly to all.”

4.1.5 Case Study Project #5

This $3.1 million traditional DBB project was part of a holistic plan for a major Port Authority to upgrade and improve the conditions of three-miles of seawall constructed over 100 years ago. A 257 workday duration was established for the project team to complete the scope. The scope for this project was to complete roof repairs and modifications on a prominent Port Pier which serves tourist and local businesses. The Pier project required hazardous material abatement, demolition, subsurface investigations, and repairs to accommodate the new roof system and surface coatings.

Some challenges associated with the project were to work within close proximity to tenants occupying local businesses, managing pedestrian traffic around the worksite, and mitigating environmental impacts. There was also a concern to avoid any impacts on a protected migratory bird population nesting during the construction period.

Partnering requirements are institutionalized in construction contracts by this local government, thus were employed on this case study project. An informal partnering charter, workshops, partnering meeting minutes, benchmarking surveys to monitor performance, and an issue resolution ladder was incorporated into the project via a neutral third-party facilitator. Three partnering workshops were held by the facilitator to parse out key project risks, performance goals, and success factors for the team. The results from the initial workshop were utilized to inform goal-aligning objectives (see Table 5-5) found within their informal partnering charter.

Table 4-5: Case Study #5 Project Charter Goals and Performance Metrics

Goal-aligning Objectives	Performance Metrics
Safety	No injuries or accidents
	Maintain a clean and safe project site
	Update local business near project of progress regularly
Schedule	Achieve scheduled milestones
	Substantial completion 11/14/17
	Final completion 12/14/17
Budgeted Cost	Less than 5% change orders
RFIs/Submittals	Exceed contract specified time (one week or less)
	All processed within two weeks with no exceptions
Environmental Impacts	No environmental non-compliance reports
Quality Control/Assurance	Weekly inspections and cleanliness
	No quality non-compliance reports
Communication/Coordination	Clearly defined communication chart followed
Public Relations	Excellent relationships with local business near project site
	No complaints or disruptions
Teamwork	Plan for long-term relationships

Nine goal-aligning objectives were identified by this project team along with clear performance metrics for each. Additionally, responsible leads were tasked with monitoring and helping to assure these goals were achieved during the project.

Notwithstanding project goals, the project team committed to an issue resolution ladder. The issue resolution ladder, as with case study #2, included five decision-making levels and time escalation processes. This also includes a similar strategy to engage a Dispute Resolution Advisor during the issue resolution process.

Comments from Case Study #5 Survey Respondents

- "Port contracts already incorporated Partnering in Project Specifications and added them to the bid item schedule."
- "Trust and respect are very solid foundations in any team integration and collaboration. Each team member should have accountability as well."

- "The contractor was familiar and comfortable with this type of work. They were pro-active and solution-oriented."

4.1.6 Case Study Project #6

The final case study project investigated in this study involved renovations to a museum building and its exhibits. The budgeted cost for the project was $5 million with an anticipated work duration of 270 workdays. The project was delivery as using a DBB project delivery method. Given that this was an existing museum facility, there were many challenges faced by the project team.

The exhibits were temporarily relocated to allow continued community enjoyment and use during construction. The scope of the project was to provide a complete interior renovation and upgrades to the museum. Some of the improvements were increased programmable space within the facility for events or classes, interactive habitat-based exhibits, and transforming the museum into a learning space for visitors and the broader community.

Several sustainable design elements were implemented in the project. They used recycled/reclaimed materials and wood, energy-efficient lighting, and low-flow plumbing fixtures in bathrooms. Other environmental friendly strategies such as locally sourced materials, recycling construction waste, and reusing materials in the project reclaimed during construction demolition activities.

The project was jointly funded by State grants, City Parks and Recreation budgeted dollars, and community fundraising support (i.e., collected by a non-profit organization that provides funds for museum activities and improvements). Considering this, myriad stakeholders were actively engaged in the design, daily oversight, construction project spending and scheduling, project partnering, and other decision-making processes. The non-profit organization maintained an ongoing wish list with targeted fundraising activities to support their added scope.

Partnering was implemented on the project to bring the stakeholders together around common goals and objectives. The project team instituted an informal partnering charter developed through partnering workshops. The workshops were led by a neutral third-party facilitator that maintained partnering meeting minutes and scorecards designed to monitor performance goals. The facilitator also worked with the team to formulate an issue resolution ladder with five levels. These issue and decision-making levels, like the other case study projects, comprised a Field level, Project level, Program level, Senior Program level, and an Executive Leadership level. The partnering facilitator was offered as a mediator when requested by the project team. As with most issue resolution ladders, the project team was bent on containing issues and resolutions at the lowest level possible.

The project team, with guidance from the facilitator, developed clear goals for the project. These became goal-aligning objectives within their partnering charter and were used as performance metrics during partnering workshop evaluations. Their partnering charter and goal-aligning objectives are shown in Table 4-6.

Table 4-6: Case Study #6 Project Charter Goals and Performance Metrics

Goal-aligning Objectives	Performance Metrics
Safety/Environmental Protection	No incidents or accidents
	No non-compliance notices
Schedule	Achieve substantial completion by 9/1/16
	Achieve final completion by 10/1/16
Budgeted Cost	Within budgeted cost of all funding sources
	Minimize change orders
	Funding stakeholders satisfaction with project
Communication/Documentation	Smooth and timely process
Quality	Meets or exceeds design expectations
	Aesthetically pleasing to all stakeholders
Public Satisfaction	Total public satisfaction, excitement, and enjoyment
Communication/Coordination	Clearly defined communication chart followed
Teamwork	Plan for long-term relationships

The project absorbed many challenges and risks as a result of several factors. One was an unanticipated electrical design and utility service improvement. The new electrical service was required by the local governing authorities and caused significant cost and schedule impacts. Another identified risk was managing the multitude of stakeholders with competing interests. This risk posed schedule concerns because payments were originating from different sources at varying times in the project. Thus, the project team had to be cognizant to monitor and control spending across the project duration.

The case study projects were detailed in the proceeding sections. Key project characteristics and partnering attributes were also summarized to illustrate how partnering was followed. The next section provides a pattern-matching of the case study projects.

Comments from Case Study #6 Survey Respondents

- "There were two sets of permit documents and several agencies beyond the client that we were contracted with that had an influence on the outcome. This, along with the issues with the electrical and fire line services were the primary complications on the project."

- "I think that the successes of the project - a quality built project, and an enjoyable experience of the team - were in large part due to the personal commitment of the team members and underlying appreciation for the mission of the organization."

4.2 Pattern-matching of Case Study Projects

The primary aim of this research is to explore the relationships between *project risk factors*, *collaborative project delivery practices*, *goal alignment*, *transactive memory systems* (TMS), and *performance outcomes* in AEC project teams. Using qualitative data, this section provides a pattern-matching of case study projects. It begins by examining the broader characteristics of the case studies investigated in this study. Then, it illustrates some commonalities and deviations within the data to help show relationships among the case study projects.

4.2.1 Characteristics of Case Study Projects

Data collected from six partnered case study projects were examined within this study. Projects varied in size, project type, complexity, and duration. Based on some of these factors, the number of people participating in partnering processes differed across projects. They were also located in two distinct regions in the U.S., West coast and the Midwest.

Table 4-7 shows the background characteristics for each case study project including project size, scheduled duration, project type, location, number of partnering participants, and number of partnering workshops. Based on this analysis, it shows that while projects are limited in regions, a good mixture of projects was represented in the analyses. For example, projects ranged in sizes with two micro ($0-$5M), two small ($5-10M), one large ($25-250M), and one very large/mega (>$250M) according to IPI vertical partnering matrix. Although, in horizontal partnering matrix projects ranging in sizes from $10-250M are combined into the large category or level 3 (IPI, 2017a).

Table 4-7: Characteristics of Case Study Projects

	Project Size (*$M)	**Schedule (**Workdays)**	*****Project Type**	**Location**	**No. of Partnering Participants**	**No. of Partnering Workshops**
Case Study #1	5.59	345	Horizontal	West	6	3
Case Study #2	4.96	255	Large Infrastructure	West	17	3
Case Study #3	149.96	595	Horizontal	Midwest	30	9
Case Study #4	272.99	1303	Large Infrastructure	Midwest	52	10
Case Study #5	3.10	257	Vertical	West	9	3
Case Study #6	5.00	270	Vertical	West	11	3

*$M – U.S. dollars in millions; **Workdays excludes holidays and weekends; *** Project types included among others vertical (e.g., office buildings), horizontal (e.g., roadways), and large infrastructure (e.g., tunnels, bridges, or major highway infrastructure)

The projects examined in this study were also grouped by project types being: two horizontal, two large infrastructure projects, and two vertical projects. When looking at the number of partnering participants it is clear that larger project included a greater number of participants. This is attributable to the number of contractors and stakeholders involved in the construction project. Similarly, the partnering workshops for projects less than $10 million in size were limited to three. These workshops, according to partnering documents, included a partnering workshop at the initial project kick-off, one midway thru the project duration, and a final workshop at or near project completion. Meanwhile, those above $10 million held partnering workshops on a quarterly basis. Partnering cost as a percentage of the original contract is given next.

The cost of partnering ranged from 0.01% of the original contract value to 0.48%. From Table 4-8 it is obvious that partnering costs are minor as compared to the overall construction budgeted cost.

Table 4-8: Case Study Partnering cost as a percentage of original contract value.

	Partnering Cost ($)	**Orig. Cost ($M)**	**Partnering Cost as a Percentage of Orig. Cost (%)**
Case Study #1	4,000	5.59	0.07
Case Study #2	8,500	4.96	0.17
Case Study #3	20,000	149.96	0.01
Case Study #4	19,000	272.99	0.01
Case Study #5	15,000	3.10	0.48
Case Study #6	10,000	5.00	0.20

A brief inspection of project delivery approach followed in each case study project showed that DBB was most prominent. This approach accounted for five of six cases in the data while case study #4 was delivered using DB. Next, cost and schedule performance outcomes are presented.

4.2.2 Cost and Schedule Growth Comparison

The case studies were also examined to understand cost and schedule growth. To do so, the original and actual cost/schedule information was collected from project participants. Two of the projects are ongoing, thus, actual cost information is tentative (i.e., case study #3 and #4). Cost growth for micro/small projects is shown in Figure 4-1.

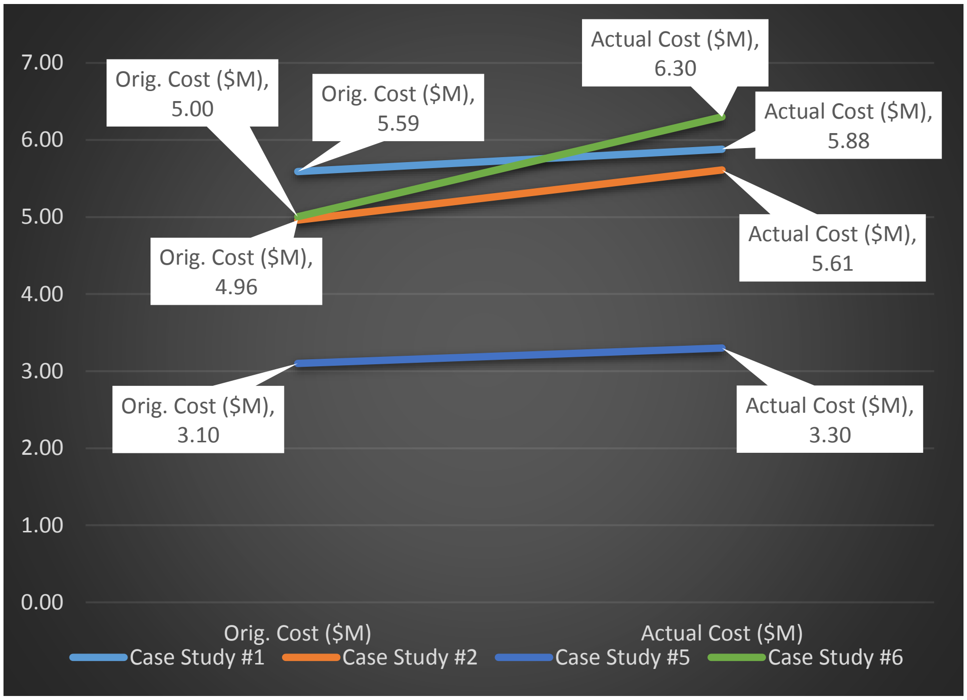


Figure 4-1: Cost Growth for Micro-Small Projects or less than $10M

Evaluating the cost growth change from original to actual cost by case study it demonstrates that case study #1 and case study #5 experience minor cost growth, 5% percent and 6% percent respectively. Case study project #2 has moderate cost growth at 13% percent while case study project #6 found significant cost growth being 26% percent. According to project team members, this is directly correlated with a major change in scope for the project. An unplanned electrical design change and new electrical utility service upgrade increased the project cost.

The large/mega projects were also evaluated to understand cost growth based on original versus actual cost. Figure 4-2 illustrates the results of two case study projects which were greater than $25 million. Both projects are seeing minimal cost growth or 3% percent (Case study #3) and 1% percent (Case study #4). Although important, both projects are ongoing which may affect these findings. Despite this, it is anticipated case study #4 will hold pretty consistent since they are in the final stage of completion only doing minor finish work (e.g., surface painting).

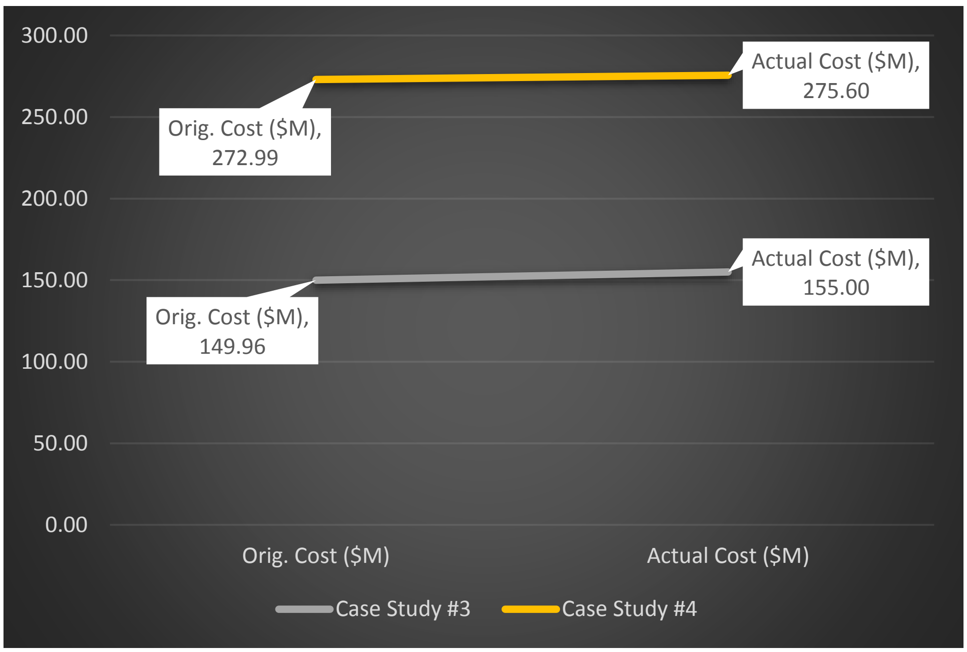


Figure 4-2: Cost Growth for Large-Mega Projects or greater than $25M

Schedule growth was also examined across all case study projects in this study. The analysis looked at scheduled durations in workdays (i.e., calendar days excluding holidays and weekends). In addition, this analysis considered the original planned duration for each project and compared it against actual project durations. The results of this analysis are shown in Figure 4-3.

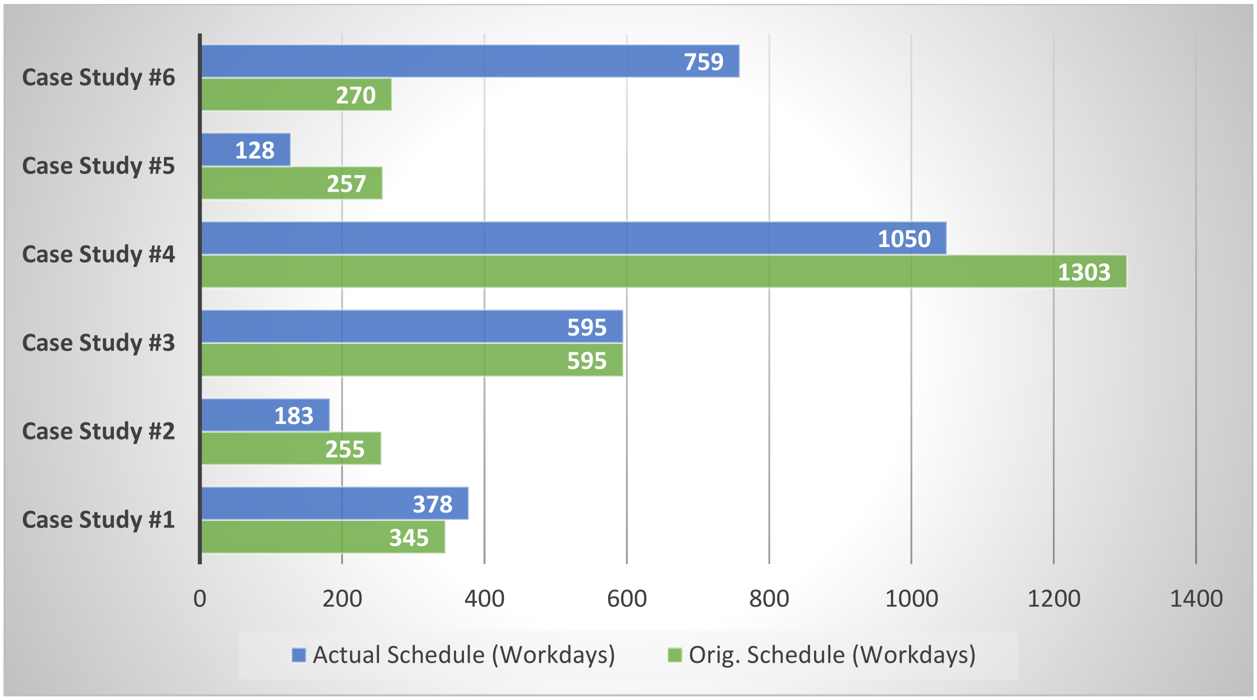


Figure 4-3: Schedule Growth for Case Study Projects based on Workday Durations

Based on the analysis, three case studies experienced considerable schedule savings. Case study #5 was completed in half the anticipated schedule duration even considering getting off to a late start. According to the project team, a hazardous material abatement contractor brought onboard for the project was replaced due to lack of experience. This change delayed the project by three months, yet the project still finished ahead of schedule. This case study project also reported a scope add during construction of an additional Pier renovation. They reported this project also finished ahead of schedule. Case study #4 also finished considerably ahead of schedule. The project team attributed their success to high levels of collaboration and coordination. This schedule improvement was due, in part, to 24-hour workdays to make up for delays associated with downtown events and redesigns to shoring systems.

The schedule growth for the case studies as a percentage are as follows: 10% percent (Case study #1), -28% percent (Case study #2), 0% percent or on target (Case study #3), -19%

percent (Case study #4), -50% percent (Case study #5), and 181% percent (Case study #6). These results are shown in Table 4.9 which communicates both cost and schedule growth, ranked on best overall project performance.

Table 4-9: Overall Project Performance Ranking

	Cost Growth	Schedule Growth	*Rank
Case Study #4	1%	-19%	1
Case Study #3	3%	0%	2
Case Study #5	6%	-50%	3
Case Study #2	13%	-28%	4
Case Study #1	5%	10%	5
Case Study #6	26%	181%	6

* Overall Project Performance Ranking based on Lowest Cost and Schedule Growth Comparison.

As previously mentioned, case study #6 saw drastic increases in their schedule due to unanticipated work. However, case study #1 also experienced a small increase in their completion schedule. According to the owner team, this was explained by a contingency add which increased the stormwater sewer replacement from six to eight city blocks.

4.3 Cross-Case Synthesis of Case Study Projects

The primary aim of this research is to explore the relationships between *project risk factors*, *collaborative project delivery practices*, *goal alignment*, *transactive memory systems* (TMS), and *performance outcomes* in AEC project teams. This section provides a cross-case synthesis of case study projects based on qualitative data. It asserts the study propositions and delves into partnering attributes and perceptions according to key metrics put forward in Chapter 3. From this analysis, it demonstrates how each proposition is supported or rejected.

The qualitative analysis in this section addresses the following questions by examining partnered-project level data in the form of partnering charters, partnering meeting minutes, scorecards, and partnering workshop evidence. These data were inspected alongside structured interviews with project stakeholders. This allowed the researcher to investigate the links among project risk factors, collaborative project delivery practices, and project performance. Three propositions were utilized to qualitatively test these assumptions:

Proposition 1: *Project risk factors change the level of collaborative project delivery practices implemented in partnered-projects.*

Proposition 2: *Collaborative project delivery practices are directly related to individuals' goal alignment perceptions in partnered-projects.*

Proposition 3: *Individuals' goal alignment perception is directly related to project performance in partnered-projects.*

4.3.1 Initial Patterns and Trends for Case Studies

The propositions in this study are addressed by inspecting case study evidence and drawing conclusions from emerging patterns. Trends within these data are also utilized to make assertions in supporting or rejecting study propositions.

The case studies are initially evaluated in a side-by-side comparison for each variable i.e., *project risk factors* and *collaborative project delivery practices*. These comparisons also include project characteristics (e.g., project cost, project duration, project type, and project delivery method), overall project performance rankings, and critical analysis to add richness and context to the results from these analyses.

Table 4-10 combines all six case study projects to permit an evaluation of project *risk factors*. An interesting pattern emerging from this figure. Case study projects with the highest rating in political significance and community interest were rated among the best performing projects. This held true across case study projects from varied sizes, durations, and project types (i.e., horizontal and infrastructure). Intuitively this finding is banal, in that, one would anticipate projects having potential long-term impacts on communities will strive for timely and successful completion. For instance, case study #3 commented during structured interviews on the disruptive nature of the construction work to traffic and neighbors living nearby as very important in daily decision-making. However, they trivialized the impact partnering had on their project success which was made more prominent during a partnering workshop. In this workshop, a noticeable friction was present. There was discussion regarding the owners' quick willingness to resort back to force accounts (i.e., cost of work based on time and material) due to lack of trust in pricing for added changes in scope. This is often attributed to the project delivery method (e.g., DBB creating an environment for contractors to monopolize changes), yet positive results were found in other case studies following this methodology.

Interestingly, case study #4, the only Design-Build project, showed the highest overall project performance ranking. It was also one of two projects with the strongest team and partnering experience within the project team. This may explain why interviewees purportedly identified partnering workshops as a great tool to continuously realign the team. Given their existing relationships, it appeared easier to push aside differences in this case study unlike case study #3. Similarly, case study number #2 found it challenging for team integration to take hold when project team members were not engaged in a timely manner. The project was also one with fewer partnering workshops (i.e., three workshops being one at initial project kickoff, one midway through the project, and a final at the end) due to its size. Thus, it may be plausible the frequency of partnering workshops should be aligned with the project teams collective experience working together and/or in the partnered-project arrangement. Despite this, the interviewees from case study #2 gave high marks for the success of the project and its team members.

Table 4-10: Project Risk Factors and Overall Project Performance Rank for Case Studies.

Project Risk Factors	Case Study #1	Case Study #2	Case Study #3	Case Study #4	Case Study #5	Case Study #6
Project Size ($M)	5.59	4.96	149.96	272.99	3.10	5.00
Project Duration (Workdays)	345	255	595	1303	257	270
Project Type	Horizontal	Infrastruc.	Horizontal	Infrastruc.	Vertical	Vertical
Project Risks*	1.5	3.0	3.0	3.0	1.0	3.0
Schedule Risks*	1.5	3.0	3.0	3.0	2.0	2.0
Project Team Relationships**	1.5	2.0	2.0	1.0	1.0	3.0
Partnering Team Experience***	1.5	1.5	2.0	2.0	1.5	2.5
Political Significance and Community Interest****	3.0	4.0	4.0	4.0	4.0	3.5
Complexity****	3.5	4.0	4.0	4.0	2.0	2.0
Project Delivery Method	DBB	DBB	DBB	DB	DBB	DBB
Overall Project Performance Rank	**5**	**4**	**2**	**1**	**3**	**6**

*1-Few to 3-Many; **1-Strong team and partnering experience to 4-No team or partnering experience; ***1-Experienced to 3-No Experience; ****1-Standard to 4-High

Next, the case studies are reordered based on their overall project performance ranking to help clearly illustrates other emerging trends within these data.

Table 4-11 shown below similarly combines *project risk factors*, yet aligns projects based on their overall project performance rank. Another pattern observed from this analysis is the notion that many project and schedule risks are also largely seen by projects with higher project success. Some of those risks permeated their way into case study partnering charters. Case study #2 specified a clear turnover date and time as a metric for the team knowing how vital it was to bring the water infrastructure back online. They also included goals formulated around safety and health considerations. Given the inherent risk of working inside confined spaces such as tunnels, it was no surprise the team made worker safety a prominent goal in their partnering charter. Project and schedule risk as these tend to drive a more concerted team effort in projects. Although, this benefit gets attenuated when liquidated damage clauses for delays or fines for safety incidents become part of contracts.

Meanwhile, case study projects with the highest level of complexity are also among those associated with increased project performance. Projects high in complexity (e.g., many stakeholders and downstream impacts if not projects are not delivered on time) tended to find ways to quickly align their goals for the benefit of the project. It should be noted that project team experience and partnering experience for the top four projects were relatively strong (i.e., ranges from 1.0 to 2.0 with one being a strong team and partnering experience) across these cases. As previously mentioned, this offers insight as to why these projects were able to find greater successes.

Table 4-11: Comparing Project Risk Factors among Overall Project Performance Rank

Project Risk Factors	Case Study #4	Case Study #3	Case Study #5	Case Study #2	Case Study #1	Case Study #6
Project Size ($M)	272.99	149.96	3.10	4.96	5.59	5.00
Project Duration (Workdays)	1303	595	257	255	345	270
Project Type	Infrastruc.	Horizontal	Vertical	Infrastruc.	Horizontal	Vertical
Project Risks*	3.0	3.0	1.0	3.0	1.5	3.0
Schedule Risks*	3.0	3.0	2.0	3.0	1.5	2.0
Project Team Relationships**	1.0	2.0	1.0	2.0	1.5	3.0
Partnering Team Experience***	2.0	2.0	1.5	1.5	1.5	2.5
Political Significance and Community Interest****	4.0	4.0	4.0	4.0	3.0	3.5
Complexity****	4.0	4.0	2.0	4.0	3.5	2.0
Project Delivery Method	DB	DBB	DBB	DBB	DBB	DBB
Overall Project Performance Rank	**1**	**2**	**3**	**4**	**5**	**6**

*1-Few to 3-Many; **1-Strong team and partnering experience to 4-No team or partnering experience; ***1-Experienced to 3-No Experience; ****1-Standard to 4-High

Enhancing the results, Table 4-12 brings in a comparison between the case study projects with the highest and lowest rankings. Results from this analysis demonstrate differences in both complexity and project team relationships, yet cases closely mirror one another in project risks. However, similar patterns emerge among political significance and community interests, project risks, and partnering team experience. One critical observation is how case study #6 reported many project risks and higher visibility for political significance and community interests while having drastically different outcomes. During structured interviews, the interviewees commented on how the project took on new challenges with added scope.

The additional work (i.e., new electrical service requirement from utility) caused significant cost and schedule impacts on the project which affected overall project performance perceptions. This is explained further as part of proposition testing section.

Table 4-12: Comparison of Highest and Lowest Overall Project Performing Case Study.

Project Risk Factors	Case Study #4	Case Study #6
Project Size ($M)	272.99	5.00
Project Duration (Workdays)	1303	270
Project Type	Infrastructure	Vertical
Project Risks*	3.0	3.0
Schedule Risks*	3.0	2.0
Project Team Relationships**	1.0	3.0
Partnering Team Experience***	2.0	2.5
Political Significance and Community Interest****	4.0	3.5
Complexity****	4.0	2.0
Project Delivery Method	DB	DBB
Overall Project Performance Rank	**1**	**6**

*1-Few to 3-Many; **1-Strong team and partnering experience to 4-No team or partnering experience; ***1-Experienced to 3-No Experience; ****1-Standard to 4-High; Indicates similar attributes

The project risk factors from these case studies are also investigated for patterns by looking for trends or commonalities and/or differences between project types. Table 4-13 is used to illustrate these attributes. A rich pattern emerges when controlling for project type (e.g., infrastructure, horizontal, and vertical) against overall top-rated project performance across four case studies. Results demonstrate that both high performing case studies share similar risks perceptions while emanating from two different project types.

For instance, both case study #3 and #4 equally reported increased project and schedule risks which can be attributed to the similarly of construction (e.g., highway and bridge repair projects with many active traffic routes nearby). Meanwhile, the lowest performing group differ across each risk category. What this illustrates is that both case study number one and six may have misalignment in their level of collaborative partnering. Especially considering that case study number one had a known level of community interest and increased complexity.

With regards to case study #6, there were many risks in the project such as working with an existing facility and a necessity to satisfy many stakeholders' objectives. They also had a project team with limited experience working together as shown by their ratings for project team relationship (i.e., 3.0 – Team has no prior experience working together but has partnering foundation) and partnering team experience (i.e., 2.5 – Some experience).

Table 4-13: Comparison of Project Type and High/Low Overall Project Performing Case Study.

Project Risk Factors	Case Study #4	Case Study #3	Case Study #1	Case Study #6
Project Size ($M)	272.99	149.96	5.59	5.00
Project Duration (Workdays)	1303	595	345	270
Project Type	Infrastructure	Horizontal	Horizontal	Vertical
Project Risks*	3.0	3.0	1.5	3.0
Schedule Risks*	3.0	3.0	1.5	2.0
Project Team Relationships**	1.0	2.0	1.5	3.0
Partnering Team Experience***	2.0	2.0	1.5	2.5
Political Significance and Community Interest****	4.0	4.0	3.0	3.5
Complexity****	4.0	4.0	3.5	2.0
Project Delivery Method	DB	DBB	DBB	DBB
Overall Project Performance Rank	**1**	**2**	**5**	**6**

*1-Few to 3-Many; **1-Strong team and partnering experience to 4-No team or partnering experience; ***1-Experienced to 3-No Experience; ****1-Standard to 4-High; Indicates similar attributes

Like case study project #2, this amplifies an instance where early team member involvement (e.g., public utility officials) and more frequent partnering workshops may have staved off the late timing for the added scope. The next section provides an analysis used to test study propositions.

4.3.2 Proposition Testing using Case Study Analysis

To test the propositions in this study the theoretical framework is used. Three propositions are tested in this study:

Proposition 1: *Project risk factors and the level of collaborative project delivery practices in partnered-projects are positively related;*

Proposition 2: *Collaborative project delivery practices and individuals' goal alignment perceptions in partnered-projects are positively related; and,*

Proposition 3: *Individuals' goal alignment perception and project performance in partnered-projects are positively related.*

Figure 4-4 recaps the metrics investigated during those interviews. The response options within each risk category are given priority based on rater perceptions' on how each risk influences their case study project. Then, a Likert scale is used to further discern its level of importance in each case study.

A similar methodology was followed with respect to *collaborative project delivery practices*. Key case study participants selected appropriate responses which were used to determine how collaborative practices were executed within their case study project. The evaluation method for this category is also shown in Figure 4-5. There were three distinct categories from which structured interview respondents could select. Those category options were contractual related practices, procurement related practices, and project related practices.

		Not important=1 to Very important=5				
Number of project risks with potential impacts on cost/time (e.g., complex design and construction, public-private partnership, compressed schedule, uncommon materials, etc.)	☐ Few ☐ Moderate ☐ Many	1	2	3	4	5
Schedule risks with potential impacts on cost/time (e.g., liquidated damage and/or incentives)	☐ None ☐ Limited ☐ Many	1	2	3	4	5
Project team relationships	☐ Team has worked together before and has solid partnering foundation ☐ Team has no prior experience working together but has partnering foundation ☐ Team worked together before but no partnering foundation ☐ Team has not worked together and has no partnering foundation	1	2	3	4	5
Team partnering experience	☐ Experienced ☐ Some experience ☐ Most team members new to partnering	1	2	3	4	5
Political significance and community interest	☐ High visibility (significant strategic project) ☐ Probable (organization image at stake) ☐ Likely, depending on the size of the client and place of importance ☐ Unlikely, unless in a place of importance	1	2	3	4	5
Complexity	☐ High (i.e., highly technical and complex design and construction; short timeline/ schedule constraints, uncommon materials, new supply chain, etc.) ☐ Increased ☐ Moderate ☐ Standard	1	2	3	4	5

Figure 4-4: Common Project Risk Factors Evaluation Method

	Yes	No	Not important=1 to Very important=5				
Contractual Related Practices							
A professional facilitator was used in this project.	☐	☐	1	2	3	4	5
A shared equity arrangement was indicated in contracts.	☐	☐	1	2	3	4	5
A partnering charter was used in this project.	☐	☐	1	2	3	4	5
A proactive conflict management tool that added structure to collaborative problem solving processes was used in this project.	☐	☐	1	2	3	4	5
Equal power/empowerment was afforded to all project teams and team members in decision-making processes.	☐	☐	1	2	3	4	5
An incentive/fee/risk-reward/ or gainshare-painshare agreement was established in contracts.	☐	☐	1	2	3	4	5
Procurement Related Practices							
Parties were selected based on partnering experience.	☐	☐	1	2	3	4	5
We selected team members based on previous work experience with other team members.	☐	☐	1	2	3	4	5
Parties were selected based on technical expertise.	☐	☐	1	2	3	4	5
There was early involvement of key participants (e.g., designer/contractor/specialty subcontractors) during schematic design (SD).	☐	☐	1	2	3	4	5
Project Related Practices							
Partnering workshops were held for this project.	☐	☐	1	2	3	4	5
Partnering scorecards were used in this project.	☐	☐	1	2	3	4	5
There were two or more project teams located together in a common office (i.e., colocation).	☐	☐	1	2	3	4	5
Partnering training/team-building sessions were held for this project.	☐	☐	1	2	3	4	5
Measurable and achievable milestones were established to determine the success of the project.	☐	☐	1	2	3	4	5
Project teams openly exchanged information across organizational boundaries (e.g., Building Information Modeling (BIM))	☐	☐	1	2	3	4	5
Quarterly partnering meetings were used in this project.	☐	☐	1	2	3	4	5
Monthly partnering meetings were used in this project.	☐	☐	1	2	3	4	5
Multi-tiered partnering was used in this project (i.e., executive, core team, stakeholders)	☐	☐	1	2	3	4	5
Specific task force used for conflict and issue resolutions	☐	☐	1	2	3	4	5

Figure 4-5: Collaborative Project Delivery Evaluation Method

Based on the theoretical framework in Figure 4-6, a direct relationship is present among variables using evidence from each case study project. Data supporting this framework are based on perceptions among individuals from each case study project along with case study project documents such as partnering charters, partnering scorecards, and insights from structured interviews.

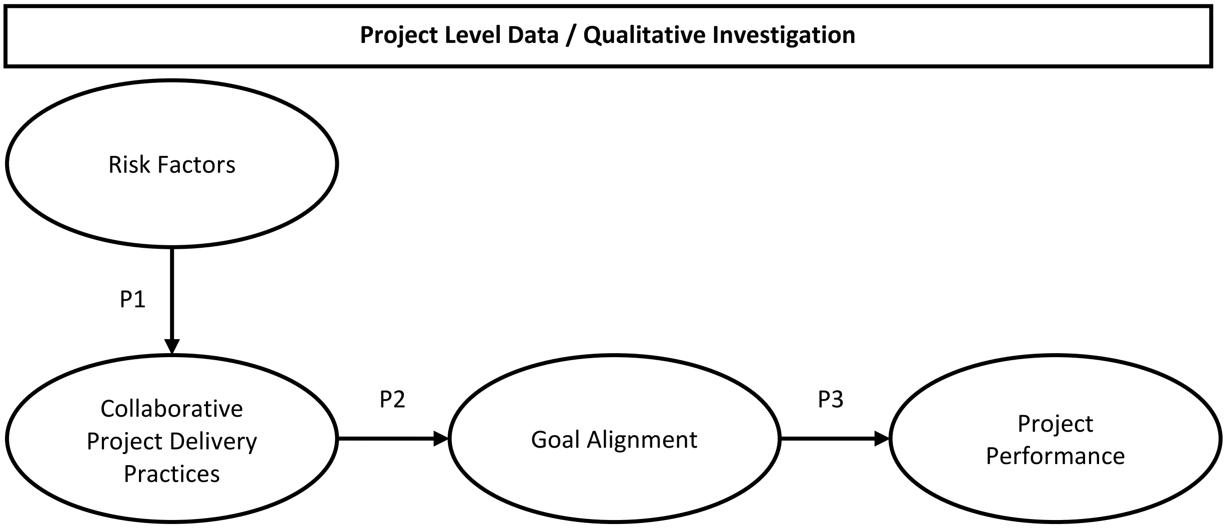


Figure 4-6: Theoretical Framework for Relationships among Project Risk Factors, Collaborative Project Delivery Practices, Goal Alignment, and Project Performance.

These data were analyzed to generate a score for each variable shown in Figure 4-6. The responses on these items were assigned a level of importance as rated by individuals' (e.g., Few=1, Moderate=2, and Many=3) which is multiplied by the rating of the item using a Likert scale ranging from 1-Strongly disagree to 5- Strongly agree. These data were weighted based on the number of choices available i.e., five response options were equally weighted as 0.2 and multiplied by the actual response. This value is, then, converted to a 100 point score by multiply by 100 and divided by the total number of responses for each category.

The scores shown in Table 4-14 are sorted by case study number and used to test the three propositions presented in this study. This table shows the results from structured interviews used to capture *project risk*, *collaborative practices*, *project performance*, and *goal alignment* perceptions from each case study project. Additionally, it gives information gathered from case study partnering documents such as partnering charters, partnering scorecards, and insights from structured interviews.

Table 4-14: Case Study Scores used in Proposition Testing sorted by Case Study Number

	Structured Interviews			Case Study Partnering Documents		
Case Study Projects	**Project Risk Factor Score**	**Collaborative Practice Score**	**Project Performance Score**	**Goal Alignment Score**	**Project Charter Goals**	**Goal Alignment Actions**
Case Study #1	44	43	88	90	9	23
Case Study #2	80	71	100	92	8	13
Case Study #3	75	41	85	71	13	49
Case Study #4	64	64	85	78	10	43
Case Study #5	44	43	100	93	9	23
Case Study #6	57	36	55	93	7	14

Proposition 1: *Project risk factors and the level of collaborative project delivery practices in partnered-projects are positively related.*

The first proposition (i.e., P1 in Figure 4-4) in this study investigates the relationship between *project risk factors* and *collaborative project delivery practices. Project risk factors* were measured during structured interviews with key owner representatives using Likert scale ratings and analyzed according to the aforementioned analyses above. The results from structured interviews and scorecards used to capture *project risk factors*, *collaborative project delivery practices*, *project performance*, and *goal alignment* perceptions from each case study project are shown in Table 4-15. The table highlights the relationship between these the two variables in proposition 1 using scores computed from structured interview and scorecard data. The table is sorted on project risk scores from highest to lowest against collaborative project delivery practice scores.

Table 4-15: Results from Structured Interviews and Project Scorecards sorted by Project Risk Scores

	Structured Interviews		
Case Study Projects	Project Risk Factor Score	Collaborative Delivery Practices Score	Project Performance Score
Case Study #2	80	71	100
Case Study #3	75	41	85
Case Study #4	64	64	85
Case Study #6	57	36	55
Case Study #5	44	43	100
Case Study #1	44	43	88

A noticeable pattern exists regarding *project risk factor* scores for each case study represented in the table. Case study #2 purportedly has the highest *project risk factor* score (i.e., 80) while case studies #1 and #5 both received the lowest *project risk factor* score in these data (i.e., 44). Juxtaposing *project risk factor* scores with *collaborative project delivery practice* scores, it appears four case study projects have clearly aligned their *collaborative project delivery practices* with *project risk factors*. In other words, when *project risks* such as complex design and construction, compressed schedules, and uncommon materials are perceived as low, the importance of *collaborative practices* is minimized. In fact, case study #1 reported the ability to take on the additional scope in the form of another two blocks of water main replacement and surface repairs associated with the low risk to the project schedule and budget.

Two of the six cases do not support the proposed relationship in proposition 1: Case studies #3 and #6. Interestingly Case study #6 has the lowest project performance score while case study #3 also has one of the lower performance scores. These results led to the development of a new proposition:

Proposition 1a - *If collaborative project delivery practices are not positively aligned with the level of project risk in partnered-projects, then project performance will be negatively affected*.

Table 4-16 is used to explicitly probe *project risk factors* identified and scored by case study project participants. The case studies are shown in order based on their overall risk scores. In addition, the specific project risk factors and characteristics of each case study are shown.

Table 4-16: Project Risk Factors and Overall Risk Scores

	Case Study #2	**Case Study #3**	**Case Study #4**	**Case Study #6**	**Case Study #5**	**Case Study #1**	**Project Risk Item Score**
Project Risk Factors							
Partnering Team Experience	100	90	90	70	90	90	**88**
Political Significance and Community Interest	100	90	80	80	30	25	**68**
Schedule Risks	90	90	90	30	40	44	**64**
Project Team Relationships	100	100	60	67	27	20	**62**
Complexity	45	40	47	42	50	45	**45**
Project Risks	45	40	20	53	25	38	**37**
Overall Risk Score	**80**	**75**	**64**	**57**	**44**	**44**	**61**
Project Characteristics							
Project Size ($M)	4.96	149.96	272.99	5.00	3.10	5.59	
Project Duration (Workdays)	255	595	1303	270	257	345	
Project Type	Infrastruc.	Horizontal	Infrastruc.	Vertical	Vertical	Horizontal	
Project Delivery Method	DBB	DBB	DB	DBB	DBB	DBB	

Despite the variation within *project risk factor* scores, five of six cases scored highly on partnering team experience. In Table 4-16 overall project risk scores are highest (e.g., ranged from 90-100) when project teams purportedly have limited partnering experience. This may serve as an early warning to project teams that *collaborative project delivery practices* are not aligned or should be equally aligned.

Meanwhile, projects with high visibility due to the impact on surrounding communities also maintain higher risk scores. This trend is most prominent in case study #2 where the project had increased exposure because it involved shutting down a regional water source for the community. Thus, the stakes for the project team were heightened which resulted in increased awareness and adhered to project goals outlined in the partnering documents. One particular item was the inclusion of advance inspections to the tunnel lining prior to repairs and construction. Unlike case study #6, there was a clear plan to deal with unforeseen conditions to help mitigate schedule impacts. The project team reported completing the project well ahead of schedule due largely to this single item.

The second highest *project risk factor* among these cases was political significance and community interest. Looking at this closer both case study #3 and #6 appeared disjointed from their *collaborative project delivery practices*, yet they ranked this risk factor as relatively important. Again, maybe project teams should place more stock in *collaborative project delivery practices* when risk factors are known. Especially those regarding limited partnering experience and newer relationships, political significance and community interest, and potential schedule risks.

Further evidence supporting proposition 1 is given in Table 4-17. Based on this table, another interesting revelation arises relating to case study #3 and #6. Both case studies noted the inclusion of incentives, fees, risk-reward, or gainshare-painshare agreements in contracts. During structured interviews, it was discovered that these were specific to liquidated damages intending to account for late project delivery. Neither case study reported the necessity to enforce liquidated damages, however, it should be noted that this tends to exacerbate project risk perceptions when not seen as equitable in multiparty agreements.

Using the above analyses, this study asserts limited support for the relationship between *project risk factors* and *collaborative project delivery practices* suggested in proposition 1. Several practical applications and theoretical implications are listed next.

Practical Applications

- When project risks are relaxed collaborative project delivery practices are easily aligned.
- Limited partnering team experience and projects with high visibility are early warning signs for increased collaborative practices.
- Avoid disincentives such as liquidated damages unless subsequent incentives or risk sharing arrangements are included in contracts.

Table 4-17: Collaborative Project Delivery Practices sorted by Overall Score

Collaborative Project Delivery Practices	**Case Study #2**	**Case Study #4**	**Case Study #5**	**Case Study #1**	**Case Study #3**	**Case Study #6**
<u>Contractual Related Practices</u>						
Professional facilitator was used in this project.	✓	✓	✓	✓	✓	✓
A shared equity arrangement was indicated in contracts.	✓	✓		✓	✓	✓
A partnering charter was used in this project.	✓	✓	✓	✓	✓	✓
A proactive conflict management tool that added structure to collaborative problem-solving processes was used in this project.	✓	✓	✓	✓	✓	
Equal power/empowerment was afforded to all project teams and team members in decision-making processes.	✓	✓	✓	✓		
An incentive/fee/risk-reward/ or gainshare-painshare agreement was established in contracts.					✓	✓
<u>Procurement Related Practices</u>						
Parties were selected based on partnering experience.	✓	✓				
We selected team members based on previous work experience with other team members.	✓	✓		✓	✓	✓
Parties were selected based on technical expertise.	✓	✓				✓
There was early involvement of key participants (e.g., designer/contractor/specialty subcontractors) during schematic design (SD).						
<u>Project Related Practices</u>						
Partnering workshops were held for this project.	✓	✓	✓	✓	✓	✓
Partnering scorecards were used in this project.	✓	✓	✓	✓	✓	✓
There were two or more project teams located together in a common office (i.e., colocation).		✓				
Measurable and achievable milestones were established to determine the success of the project.	✓	✓	✓	✓	✓	✓
Partnering training/team-building sessions were held for this project.	✓	✓	✓	✓	✓	✓
Project teams openly exchanged information across organizational boundaries (e.g., Building Integrated Modeling (BIM))	✓	✓	✓	✓	✓	✓
*Quarterly partnering meetings were used in this project.	✓	✓	✓	✓	✓	✓
Multi-tiered partnering was used in this project (i.e., executive, core team, stakeholders)		✓				
Specific task force used for conflict and issue resolutions	✓	✓				
Overall Collaborative Practice Score	**71**	**64**	**43**	**43**	**41**	**36**

Theoretical Implications

- Departing from literature, early involvement of key participants (e.g., designer/contractor/specialty subcontractors) during schematic design) did not appear significant in this study (Baiden et al., 2003; Cheng & Li, 2002; Pishdad-Bozorgi & Beliveau, 2016) although this was alluded to by project participants as important.
- Colocation, a common collaborative project delivery practice, was identified in only one case study despite tremendous benefits asserted in the literature (Baiden et al., 2003; Pishdad-Bozorgi & Beliveau, 2016).
- Relational governance structures are best when incentives are included in contracts, yet disincentives may disparately affect performance outcomes (Lu et al., 2015).

Proposition 2: *Collaborative project delivery practices and individuals' goal alignment perceptions in partnered-projects are positively related.*

This proposition examines the direct relationship between *collaborative project delivery practices* and *goal alignment* as presented in Figure 4-4. To examine this relationship, this study uses partnering documents (e.g., partnering charters, workshop meeting minutes, and partnering scorecard surveys) and data from structured interviews. The results from these are highlighted in Table 4-18.

From initial inspection, no discernable pattern emerges among these data. When *collaborative project delivery practices* are at the highest rating, *goal alignment* scores are also rated them highest. The same is true for the lowest scores for these two categories. Despite this inconsistent pattern, another alternative explanation persist.

Table 4-18: Results from Structured Interviews and Project Scorecards sorted by Collaborative Project Delivery Practice Scores

	Structured Interviews			Case Study Partnering Documents		
Case Study Projects	Project Risk Factors Score	Collaborative Project Delivery Practices Score	Project Performance Score	Goal Alignment Score*	Project Charter Goals	Goal Alignment Actions
Case Study #2	80	71	100	92	8	13
Case Study #4	64	64	85	78	9	23
Case Study #5	44	43	100	93	7	14
Case Study #1	44	43	88	90	9	23
Case Study #3	75	41	85	71	13	49
Case Study #6	57	36	55	93	10	43

The *goal alignment* scores are measured using defined goal alignment objectives and actions put forward by case study project teams. These are clearly elicited in partnering charters developed at outset of a project either during planning or early during phases of construction. A closer look at the number of goals in each partnering charter and number of goal alignment actions show an increasing trend as *collaborative project delivery practices* decrease. In other words, an inverse relationship appears between these two variables. Case studies with higher *collaborative project delivery practices* appear to require fewer goal alignment actions or metrics to hold the project team accountable. This leads to a new proposition:

Proposition 2a – *Higher collaborative project delivery practices require fewer goal alignment actions or metrics to hold the project team accountable in partnered-projects.*

Additional insights are found by discriminating explicitly for high and low *project risk factors*, *collaborative project delivery practices*, *goal alignment*, and *project performance* among these six cases. To do so, each score computed in Table 4-18 was converted to a high or low value by centering the score about the mean for each of the four categories. This allowed the researcher to search for variation among all categories within these data. The results are shown in Table 4-19.

In this analysis, a pattern materializes when inspecting the relationship between *collaborative project delivery practices* and *goal alignment* from a different purview. When both *project risk factors* and *collaborative project delivery practices* are rated as “High” and *goal alignment* is also “High,” case studies performance well in *project performance.* Next, when case studies share “Low” *project risk factors* and *collaborative project delivery practices*, they prove “High” *goal alignment* does not immediately afford increased project performance. A particularly interesting phenomenon shows “Low” *goal alignment* is associated with “Low” project performance perceptions. This indicates misalignment among project teams, likely attributable to poorly matching *project risk factors* with the *collaborative project delivery practices*. Especially considering the high number of goal alignment actions taken up in project charters intending to help project teams manage their goals and objectives. The researcher made similar observations when visiting case study #3.

The project team appeared challenged to assure themselves everyone’s goals were united despite the various collaborative practices designed to do so. This left many project team members in a place of mistrust and may have led to lower than expected project performance ratings. Therefore, project teams should be mindful that *collaborative project delivery practices* are only effective when they bring increased alignment among project teams. Practical and theoretical applications based on proposition 2 are offered next.

Table 4-19: Results from High/Low Score Analysis sorted by Case Study

	Structured Interviews			Case Study Partnering Documents		
Case Study Projects	**Project Risk Factors**	**Collaborative Project Delivery Practices**	**Project Performance**	**Goal Alignment**	**Project Charter**	**Goal Alignment Actions**
Case Study #1	Low	Low	High	High	9	23
Case Study #2	High	High	High	High	8	13
Case Study #3	High	Low	Low	Low	13	49
Case Study #4	High	High	Low	Low	10	43
Case Study #5	Low	Low	High	High	9	23
Case Study #6	Low	Low	Low	High	7	14

Practical Applications

- Project teams should be cautious when many goal aligning action surface during partnering workshops; Leading indication that project team may be strained to align individual goals with those outlined in the project charter

- Project deemed as having reduced project risk and following a limited number of collaborative practices should not fall into complacency; Despite the ability to keep their teams aligned, these projects are susceptible to undesirable project performance outcomes

Theoretical Implications

- Social loafing arises in this proposition where project teams or members may take a backseat because the number of goal alignment actions becomes overwhelming (Harkins, 1987; Lam, 2015).

- Larger project teams may also succumb to the social loafing phenomenon during partnering workshops and not fully commit to the partnering process (Lam, 2015).

- Goal alignment influences performance outcomes when feedback is present which is missed when project teams or individuals are not engaged in partnering and its feedback processes [i.e., workshops, scorecards, meetings, etc.](Earley, 1990; Lahdenperä, 2012; Pishdad-bozorgi & Beliveau, 2016).

Proposition 3: *Individuals' goal alignment perception and project performance in partnered-projects are positively related.*

The third proposition examines the direct relationship between *goal alignment* and *project performance* as presented in Figure 4-4. When examining the relationship between *goal alignment* and *project performance* a clear trend is present. Table 4-20 below, again, shows the results from structured interviews used to capture *project risk factors*, *collaborative project delivery practices*, *project performance*, and *goal alignment* perceptions from each case study project.

Table 4-20: Results from Structured Interviews and Project Scorecards sorted by Goal Alignment Scores

	Structured Interviews			Case Study Partnering Documents		
Case Study Projects	**Project Risk Factor Score**	**Collaborative Delivery Practices Score**	**Project Performance Score**	**Goal Alignment Score***	**Project Charter Goals**	**Goal Alignment Actions**
Case Study #5	44	43	100	93	9	23
Case Study #6	57	36	55	93	8	13
Case Study #2	80	71	100	92	13	49
Case Study #1	44	43	88	90	10	43
Case Study #4	64	64	85	78	9	23
Case Study #3	75	41	85	71	7	14

Table 4-20 highlights the relationship between *goal alignment* and *project performance*. Goal alignment scores are gathered from individual ratings against specific goals outlined and monitored as part of their project charters. Figure 4-7 presents a sample scorecard with results

PROJECT SCORECARD No. 1

GOALS / OBJECTIVES	ACTIONS / TIME FRAME	PERFORMANCE METRIC	SCORES* 1=L/5=H	COMMENTS (optional)
Safety	▪ Follow approved safety and traffic control plans and procedures ▪ Maintain a 5" safe path of travel at all times ▪ Keep site clean	Zero accidents / injuries Excellent housekeeping	4.5 (5)	
Schedule	▪ Pro-active planning and sequencing of activities ▪ Submit detailed 4-Week Look Ahead Schedule weekly, include dates for inspections and notifications to public ▪ Update Critical Path and submit monthly	Early completion Substantial Completion 7/21/17 Final Completion 8/26/17	4.0 (4)	
Budget	▪ Monitor Potential Change Orders (PCOs) closely and often; inform PM of PCO's ASAP ▪ Identify potential cost savings opportunities	PCO's and CO's kept to a minimum Contingency not exceeded Cost savings documented	4.25 (4)	
Submittals: GI / Landscaping	▪ Maintain Submittal Log and report on status @ each Progress Meeting ▪ Submit all GI submittals for review and approval by July 15th	Submittal process timely and well managed	3.9 (4)	Received from and responded to CM directly Some submittals are late and need to be expedited
Environmental Compliance	▪ Follow contractual requirements for environmental mitigation ▪ Cleanup continuously soil spills, track-out and debris; daily cleaning of parking lanes, streets and roads	No non-compliance notifications Able to eat off the street	4.2 (4)	Exceptional job considering waste accumulated from residents
Green Infrastructure Quality	▪ Schedule coordination pre-activity meetings in advance of work ▪ Regularly hold comprehensive GI tailgates in the field ▪ Install GI materials without negative impacts	No rework GI plans & specifications interpreted correctly and/or clarified & agreed upon	4.4 (5)	Only very minor rework, near perfect
Organization: Communication/Coordination	▪ Pro-active open and honest communication ▪ Issues clarified prior to writing RFI – visit site and discuss ▪ Timely notification of required coordination meetings SFWD-CDD	Organization streamlined Responsive decision making	4.4 (5)	Great working relationship/trust/ open communication.
Community Appreciation	▪ Intent and value of project recognized ▪ No impacts made to driveways/ permanent pavement ▪ Minimal loss of parking due to construction work	No complaints Timely notifications of scheduled work Project's progress documented regularly	4.7 (4)	
Team & Project Recognition	▪ Team members' roles and responsibilities respected ▪ All outstanding Field Issues addressed in a timely manner ▪ Pride in work accomplished	Respect and trust exhibited by all Team members No issues raised above project level Project recognized for GI advanced work achievement	4.8 (5)	
		1= Low / 5=High	Av. 4.3 (#responses)	

Figure 4-7: Sample Case Study Project Scorecard, Goal Aligning Actions, and Performance Metric

from one of the case study project charters investigated in this study. Each case study project followed a similar strategy which includes action items and performance metrics for the team to use in their ratings. Based on the scores developed using individuals' perceptions, a clear trend is illustrated connecting goal alignment to project performance. Generally, when goal alignment is high project performance also receives a high score (see Table 4-20).

Case study #6 appears inconsistent with the trends. In this case study, the team experienced a project set-back resulting from the added scope for an unforeseen code requirement. An electrical service was required to be upgraded as part of the renovation work. This required significant communication and coordination with the electric utility, designers, owners, and contractors. As a result, the project was delivered over two years later than originally planned. According to partnering documents, the project was financially constrained due to multiple funding sources and spending stipulations (i.e., 45 percent State grant, 30 percent City Parks and Recreation Department, and 25 percent not-for-profit fundraising by the organization). This can limit the amount of resources available for early site investigations.

Case study #6 also heavily relied on the owners' team for significant programming guidance during the design phase. As a not-for-profit organization (i.e., in this case, the owner), it can be asserted that they may not have been a sophisticated buyer of construction work and may have experienced breakdowns in communication with the designer leading to this unforeseen major scope addition. Given all this, an explanation surfaces as to why the project maintained a high goal alignment level, yet reported a lower project performance score. In contrast case studies #2 and #5 demonstrate a clear relationship between goal alignment and project performance.

The top two projects (i.e., case study #2 and case study #5) followed common metrics that differed from case study #6. For instance, an emphasis was placed on continuously improving document management systems for processing submittals and requests for information (RFIs). This allows information to move quickly across organizations when decisions are required. Another disparate finding among the top and lowest cases is the inclusion of a monitor to help encourage collaboration and integrated teams to develop, especially around problem-solving. These results lead to the development of a new proposition:

Proposition 3a: *- Collaborative delivery practices should accommodate continuous improvement in facilitating information exchange among team members in partnered-projects.*

Interestingly, the goal alignment actions for most case studies are similar across traditional areas of focus in the projects (e.g., schedule, safety, and cost). A full listing of case study project goal alignment metrics is displayed in Table 4-21. This table clearly illustrates the top three goal alignment metrics used as 1) schedule, 2) safety, and, 3) communication and coordination. All of the metrics shown in the table were used as a means to track and monitor how well the project teams were aligned with the project goals identified by the team.

One of the top performing projects, case study #2, also shares goal alignment attributes with case study #3. Both projects found it important to maintain confidence in their issue resolution ladders. This allows the project team to focus on ways to keep decisions at the lowest possible levels to assure timely responses. They also sought means to anticipate project risks early and often. Their aims were to address the issues cohesively as a team yet resolving them at the field level.

Table 4-21: Goal Alignment Metrics used in Case Studies sorted by Project Performance

Goal Alignment Metrics and Ratings*	Case Study #2	Case Study #5	Case Study #1	Case Study #3	Case Study #4	Case Study #6	# of Case Studies Following Metric
Safety	4.4	4.6	4.7	4.2	4.1	5.0	6
Schedule	5.0	4.6	4.2	3.6	3.8	4.0	6
Communication and coordination	4.3	4.6	4.6	3.2	3.7	4.9	6
Budget		4.0	4.6	3.1		4.4	4
Quality control/quality assurance			4.7	3.4	3.9	4.8	4
Environmental compliance		4.4	4.3	4.0	3.9		4
Contract Documents/Submittals/RFIs	4.2	5.0	4.1				3
Public/Neighborhood relations		4.8			4.0	4.5	3
Team and project recognition while having fun			4.9	3.6		4.0	3
Timely decision making at the lowest level possible using issue resolution ladder	4.4			3.5	3.8		3
Integrated team response/Teamwork	4.8	5.0					2
Community appreciation		5.0	4.6				2
Anticipate project risks and address emerging issues collectively	4.8			3.5			2
Trust and respect each other and all the partners on the project including all stakeholders (e.g., public, local government, utilities, permitting agencies, etc.)				3.4	3.7		2
Focus on the Project first and empower people to follow this principle				3.4	3.9		2
Reasonable profit incentive for contractors				4.2			1
Seize opportunities to improve project outcomes when they arise (Lessons Learned)				3.3			1
Total Number of Goal Alignment Metrics	**7**	**9**	**9**	**13**	**9**	**7**	
Project Performance Score	**100**	**100**	**88**	**85**	**85**	**55**	

Another observation from Table 4-21 was how the project with the greatest number of goal alignment metrics (i.e., case study #3) did not score equally high in project performance ratings. This is likely attributable to a tendency to underestimate one's performance over a longer time span. For example, case studies #3, #4, and #6 all lasted for longer durations (e.g., 595, 1050, and 759 workdays respectively) as compare to the other three case study projects (i.e., 378, 183, and 128 workdays for case studies #1, #2, and #5 respectively). Additionally, case study projects #3 and #4 both had nine scorecards and partnering workshops up to the point of data collection. Figure 5-8 illustrates the trends over time for these two cases.

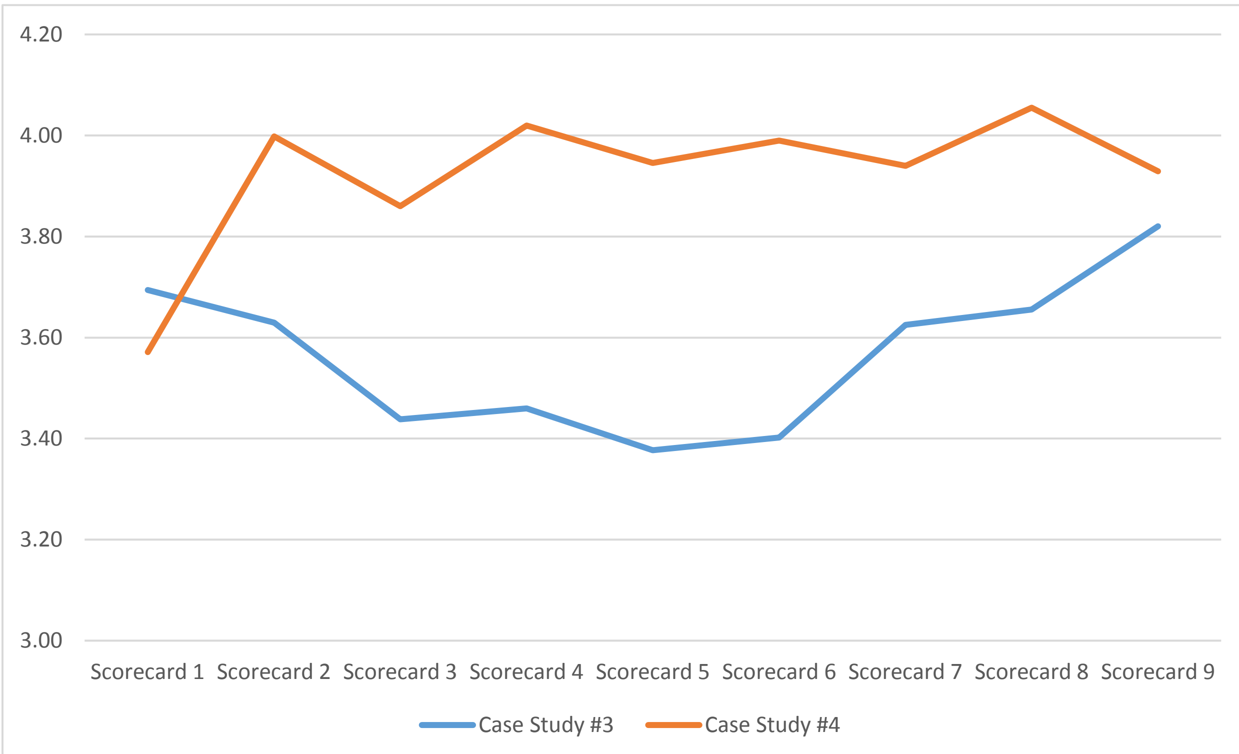


Figure 4-8: Goal Alignment ratings from Scorecards (Large-Mega)

Examining Figure 4-8 it becomes more apparent how project teams may not always remain contiguously aligned with the project goals. This is evinced by case study #3 where the goal alignment scores dipped over the project duration then rebounded near the later period of the recorded project team ratings. Case study #3, based on observational data during a site visit, frequently dealt with challenges regarding pricing change orders. The level of trust had been challenged the team confronted risk management from disparate perceptions as the owner versus the contractor. When pricing extra work, the contractor encountered risk in pricing added scope too low while the owner believed they often were forced to accept a price that was too high. The alternative was to utilize force accounts which are intended to resolve concerns when negotiated pricing between the owner/design and contractor are untenable. Thus, it becomes obvious that an individual rater would find it hard to disentangle these types of concerns from project performance perceptions. Although, the researcher observed the project team was willing to agree levels of trust will never reach 100 percent. They also maintained a sound level of informal dialogue and offered kudos to many team members shortly after a spirited problem-solving exercise orchestrated by their neutral third-party partnering facilitator.

Table 4-22 further communicates how *goal alignment* and *project performance* are related. The table identifies additional case study characteristics being 1) a formal partnering charter codified with signatures was used; 2) timing of partnering charter implementation; 3) the parties involved in the development of partnering charter; 4) clarity of goals communicated in partnering charter; and, 5) number of goal alignment metrics. Follow up procedures used by each case study project are also shown in Table 4-22. These include number of partnering workshops, number of attendees at partnering kickoff meeting, number of partnering scorecards surveys completed, and number of team building exercises.

There is one clear trend among the projects with lower project performance ratings. The number of stakeholders involved in developing the partnering charter was complete with the owner, design, contractor, and others for the lower performing projects. This indicates a challenge may persist in achieving and maintaining goal alignment when multiple stakeholders are involved. Moreover, there may be a tending to include competing goals and objectives.

An example of competing interests arises in case study #3 whereby the partnering charter includes two goal alignment metrics as follows:

- "Complete the project on budget and within budget"
- "Afford Contractor A and its subcontractors the opportunity to make a profit"

This idea, while seemingly harmless, may have influenced the travails the project team experienced with trust. The owners' team subconsciously remains attached to completing the project in line with cost and schedule goals. Meanwhile, the contractors' team is generally concerned with making a profit and must be delighted to find this codified in the partnering charter. This creates a perfect storm for skepticism among project teams casting doubt on motives for negotiated prices of extra work.

Table 4-22: Goal Alignment and Congruence items from Partnering Documents

Goal Alignment and Congruence	Case Study #2	Case Study #5	Case Study #1	Case Study #3	Case Study #4	Case Study #6
Project Charter						
Formal Charter including Project Team Signatures	N	N	N	Y	Y	N
Timing of Charter (e.g., # of months before or after construction(CNST))	4-Months after CNST	2-Months before CNST	5-Months after CNST	1-Month before CNST	2-Months before CNST	2-Months after CNST
Parties involved in Developing Charter (e.g., Owner-O, Designer-D, Contractor-C, Other Stakeholders-S)	O, C	O, C	O, D, C, S	O, D, C, S	O, D, C, S	O, D, C, S
Clarity of Goals (i.e., More than three clear and detailed action items)	N	Y	N	Y	Y	N
Number of Goals	9	9	7	13	9	7
Follow up Procedures						
Number of Workshops	3	3	3	9	9	3
Number of Attendees at Partnering Kickoff Meeting	17	9	6	30	52	11
Number of Partnering Scorecard Surveys	1	5	2	9	9	2
Team building training lessons	N	N	N	Y	Y	N
Project Performance Score	**100**	**100**	**88**	**85**	**85**	**55**

Proposition 3 is supported in this study based on the analyses above. Next, a list of both practical application and theoretical implications are given. Further details are provided in Chapter 6 findings and discussions.

Practical Applications

- Focus on a core set of goal alignment metrics that are detailed around a clear project objective.
- Anticipate goal alignment deviates over projects with longer durations and make provisions to continuously reinforce them.
- Avoid competing goal objectives within partnering charters.

Theoretical Implications

- Relational governance permeates these case studies (Carson et al., 2006; Ouchi, 1980; Williamson, 1979)
    - Flexibility, solidarity, and information exchanges strategies followed to encourage trust.
    - Benchmarking metrics, partnering workshops, and conflict resolution strategies are not memorialized in the contracts.
    - Opportunisms concerns due to memorializing conflicting goals in project charter resorting back to TCE theory.
- Goal aligning feedback and goal congruence surfacing within case studies

- Neutral third-party facilitators used during partnering workshops to continuously bring project teams into alignment around project goals and objectives (Cheng & Li, 2002; Manley, Mcfallan, & Kajewski, 2009).
- Shared risk and reward structures did not necessarily lead to improved performance, although these were primarily risk structures [e.g., liquidated damages for late project completion](Manley et al., 2009; Pishdad-Bozorgi & Beliveau, 2016).

4.4 Summary

Chapter 4 presented the qualitative analyses emanating from this study. A summary of each case study project was given. Then, the researcher used pattern-matching to extend descriptive characteristics for the case studies including cost and schedule results. The chapter then shifts focus towards its determination to illustrate additional patterns and trends. This cross-case synthesis approach allowed for proposition testing which ends Chapter 4. The next chapter provides results from quantitative analyses of survey data collected as part of each case study.

CHAPTER 5 QUANTITATIVE ANALYSIS

Chapter 5 provides quantitative analyses and results based on evidence collected from online surveys. These data were analyzed using Mplus Version 8 software package (Muthén & Muthén, 2017). The chapter begins by summarizing case study data demographics, then gives a summary of the latent variables and factors underlying each variable in the survey. Next, the results from the model put forward in this study are analyzed using confirmatory factor analysis. The final section ends with hypothesis testing using multiple regression/correlation analysis (MRC) and summarizes the findings.

The primary goal for this stage of the research was to quantitatively examine the following at individual-level in interorganizational AEC project teams:

1. The relationship between *individual/team performance*, *goal alignment,* and *TMS*.

To do so, the researcher used confirmatory factor analysis (CFA) to test the proposed factor structure and estimate factor scores for *goal alignment*, *TMS*, and *individual performance* constructs. Multiple regression/correlation analysis (MRC) was used for hypothesis testing of relationships among the constructs and respond to the research questions. The model developed in this study was used to test the following hypotheses:

Hypothesis 1: *Individual performance in partnered-projects is directly related to individuals' goal alignment perception.*

Hypothesis 2: *Individuals' TMS moderates the relationship between individuals' goal alignment perceptions and individual/team performance in partnered-projects.*

The researcher used Mplus Version 8 (Muthén & Muthén, 2017) in all statistical analyses. All of the statistical analyses performed were used to assess the measurement model, model fit, along with the underlying factor structure of the data. The analyses for all data collected in surveys was treated as categorical in CFA and MRC. The case study data demographics are given next followed by results from CFA.

5.1 Case Study Data Demographics

Six public case study projects were used in this study to address the research questions and for hypothesis testing. The case study sample demographics are shown in Table 5-1 including among other things project size, schedule, project type, project delivery method, and location. These case studies were utilized to investigate the relationships among *goal alignment* and *performance outcomes* moderated by *transactive memory systems*.

An online survey was used to collect individual-level data from the case study project participants. Overall there were 125 potential partnering participants across six cases. The online survey was accessed by 69 participants while 51 surveys were sufficiently completed to permit further data analyses. Table 5-2 displays the number of survey responses, partnering participants, and response rates for each case study. Each case study was represented in online survey data. Four of six case studies had a response rate above 30 percent while case study number #3 was 27 percent and case study number #6 was 20 percent. The final response rate for this study was 41 percent.

Table 5-1: Case Study Sample Demographics

	Project Size (*$M)	Schedule (**Workdays)	***Project Type and Delivery Method	Location	No. of Partnering Participants	No. of Partnering Workshops
Case Study #1	5.59	345	Horizontal/DBB	West	6	3
Case Study #2	4.96	255	Large Infrastructure/DBB	West	17	3
Case Study #3	149.96	595	Horizontal/DBB	Midwest	30	9
Case Study #4	272.99	1303	Large Infrastructure/DB	Midwest	52	10
Case Study #5	3.10	257	Vertical/DBB	West	9	3
Case Study #6	5.00	270	Vertical/DBB	West	11	3

*$M – U.S. dollars in millions; **Workdays excludes holidays and weekends; *** Project types included among others vertical (e.g., office buildings), horizontal (e.g., roadways), and large infrastructure (e.g., tunnels, bridges, or major highway infrastructure)

Table 5-2: Summary of Study Sample and Responses

	No. of Survey Respondents	No. of Partnering Participants	Response Rate
Case Study #1	5	6	83%
Case Study #2	9	17	53%
Case Study #3	7	30	23%
Case Study #4	22	52	43%
Case Study #5	5	9	56%
Case Study #6	3	11	27%
Overall Participant Totals	**51**	**125**	**41%**

The respondents in this survey also varied across roles in each case study. The data shown in Table 5-3 illustrates the spread among roles identified in survey responses. Based on the table, Owner or Owners' Representatives are the largest group of respondents in this study (n=24). Meanwhile, the Contractor group are second with (n=11) response. No external stakeholders responded to the survey. Four individuals selected the role of facilitator, however, they noted in text response the role of Construction Manager or Independent Construction Quality Manager. The role listed as others included Independent Construction Quality Managers (n=2), Safety Managers (n=2), and Construction Inspectors (n=1).

Table 5-3: Respondent Demographics based on Project Role

Project Role	Case Study #1	Case Study #2	Case Study #3	Case Study #4	Case Study #5	Case Study #6	Totals
Owner or Owners' Rep	2	2	4	13	2	1	**24**
Facilitator	0	3	0	1	0	0	**4**
Designer/Engineer	1	0	1	2	1	0	**5**
Contractor	2	2	1	3	1	2	**11**
Subcontractor	0	1	0	1	0	0	**2**
Other*	0	1	1	2	1	0	**5**
Total # of Respondents	**5**	**9**	**7**	**22**	**5**	**3**	**51**

*Others rated their role as Independent Quality Manager, Safety Manager, or Construction Inspector

5.2 Confirmatory Factor Analysis

CFA is used to test a priori hypotheses about relations between observed variables and latent variables or factors (Jackson, Gillaspy, & Purc-Stephenson, 2009). The objective is to estimate a population covariance matrix that is compared with the observed covariance matrix. The goal is to minimize the difference between the estimated and observed matrices.

CFA is used in this study to validate how well the hypothesized model fits the data. Goodness-of-fit summary statistics for the measurement models are confirmed using three fit indices, Chi-Square (x^2) test of model fit, root mean square error of approximation (RMSEA), and comparative fit index (CFI). Indications of good model fit using Chi-Square (x^2) is a low x^2 relative to degrees of freedom with a high *p* - value (p > .05), RMSEA values between 0.08 to 0.10 (adequate fit) and less than 0.07 (good fit), and CFI $\geq$ 0.95 (Hooper, Coughlan, & Mullen, 2008).

The latent variables in this study were treated as categorical to improve the data structure. The full measurement model was then estimated using summed scale scores across each of the latent variables. The fit statistics for the final measurement model demonstrates the model fits the data (x^2 = 38.46, *df* = 33.0 *p* = 0.24, RMSEA = 0.06, CFI = 0.98). Detailed results of statistical analyses for the final measurement model are shown in Appendix C. Next, each latent variable is illustrated along with its underlying data structure.

Goal Alignment Latent Variable

There were five indicators underlying the latent variable for *goal alignment*. The latent construct for *goal alignment* and its indicators are shown in Figure 5-1 below. Detailed results of statistical analyses for the latent variable goal alignment are shown in Appendix D.

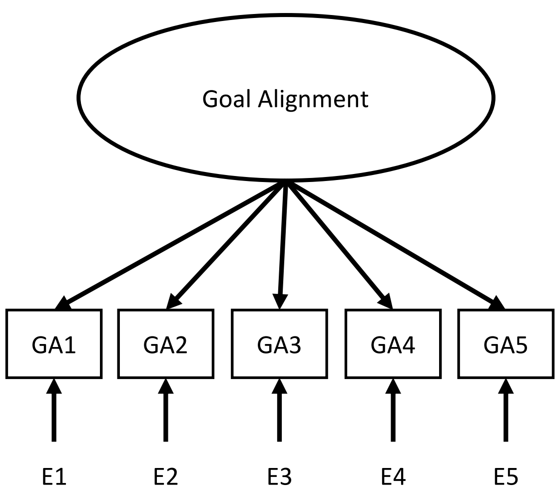


Figure 5-1: Goal Alignment Latent Variable and Factor Indicators

Each measurement indicator represented in Table 5-1 is described and shown with its factor loading (see Appendix D for detailed statistical analyses). The resulting standardized factor loadings and standard errors (S.E.) from CFA were [GA1 = 0.79 (0.08), GA2 = 0.99 (0.06), GA3 = 0.76 (0.07), GA4 = 0.92 (0.10), and GA5 = 0.78 (0.11). All factors were retained in this analysis as they were significant at 0.05 level of significance. The fit statistics for *goal alignment* validates the model adequately fits the data (x^2 = 7.61, *df* = 5.0, *p* = 0.18, RMSEA = 0.10, CFI = 0.99).

Table 5-4: Factor Structure and Factor Loadings for Goal Alignment

Factor Structure	**CFA Factor Loadings (standardized estimates, p< .05)**
<u>Goal Alignment (GA)</u>	
Mutual goals and objectives in the partnering charter were communicated effectively (GA1).	0.78
Clear and compatible partnering goals were established by the project team (GA2).	0.99
I generally agreed with project-related goals established by the project team (GA3).	0.76
My attitude towards project-related goals established by the project team were similar (GA4).	0.92
My goals for the project were in close alignment with the project team (GA5).	0.78

Transactive Memory System (TMS) Latent Variable

TMS was measured using three sub-factors, coordination, communication, and specialization to form the higher order latent variable. The factor structure for *TMS* is shown in Figure 5-2.

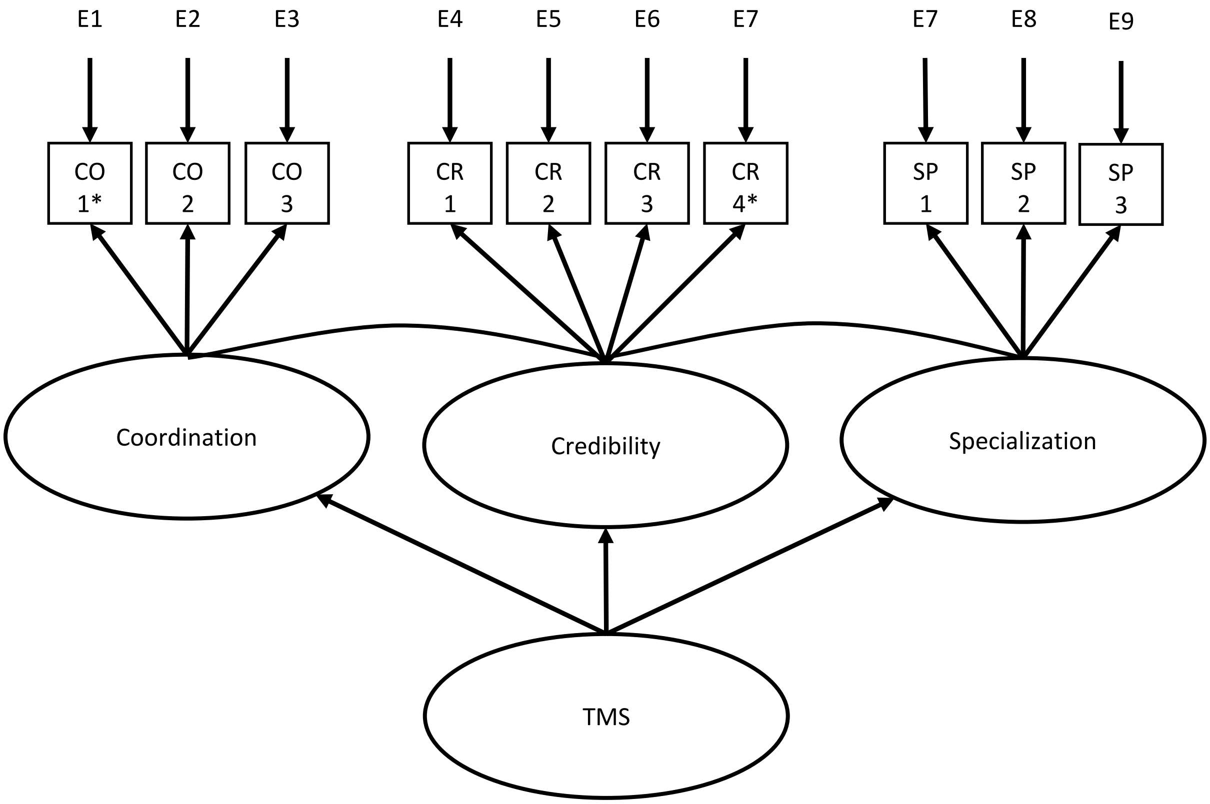


Figure 5-2: Factor Structure for the TMS Latent Variable; * Indicators with weak loadings or negative residual variances

The sub-factor structure illustrated in Figure 5-2 shows eight underlying indicators while results are described in Table 5-2 (See Appendix D for detailed statistical analyses).

The results of CFA demonstrated several weak factors of *TMS* being (CO1) and (CR4). These indicators had either weak loadings or negative residual variances, thus were removed from CFA model to improve model fit. The rest of the factors were retained at 0.05 level of significance and used in CFA to test the model fit. The standardized factor loadings and standard errors (S.E.) are given as [CO2 = 0.94 (0.08), CO3 = 0.80 (0.10), CR1 = 0.66 (0.12), CR2 = 0.99 (0.05), CR3 = 0.92 (0.04), SP1 = 0.42 (0.15), SP2 = 0.40 (0.16), and SP3 = 0.92 (0.16)]. The fit statistics for *TMS* validates the reduced model adequately fits the data (x^2 = 23.62, *df* = 17.0, *p* = 0.13, RMSEA = 0.09, CFI = 0.99).

Table 5-5: Factor Structure and Factor Loadings for Transactive Memory Systems

Factor Structure	Higher-order Factor Loadings (standardized estimates, p< .01)	Sub-Factor Loadings (standardized estimates, p< .01)
Coordination (CO)	0.86	
The project team had very few misunderstandings about what to do during construction (CO2).		0.94
I believe we accomplished our task for the project smoothly and efficiently (CO3).		0.80
Credibility (CR)	0.92	
I was comfortable accepting procedural suggestions from other team members (CR1).		0.66
I trusted that other members' knowledge about the project was credible (CR2).		0.99
I was confident relying on the information that other team members brought to the discussion (CR3).		0.92
Specialization (SP)	0.83	
I understand what skills my team members have and domains they are knowledgeable in (SP1).		0.42
The specialized knowledge of several different team members was needed to complete the project (SP2).		0.40
Overall, I am able to access other team member's thinking and knowledge (SP3).		0.92

Individual/Team Performance

There are three dimensions that were assessed in this study regarding the latent variable *individual/ team performance*. The three sub-factors were *project related*, *communication-related*, and *team related*. The number underlying indicators for each of the sub-factors were (8) *project performance*, (4) *communication performance*, and (7) *team performance.* Figure 5-3 illustrates the latent variable for *individual/team performance* and its resulting factor structure is shown in Table 5-3.

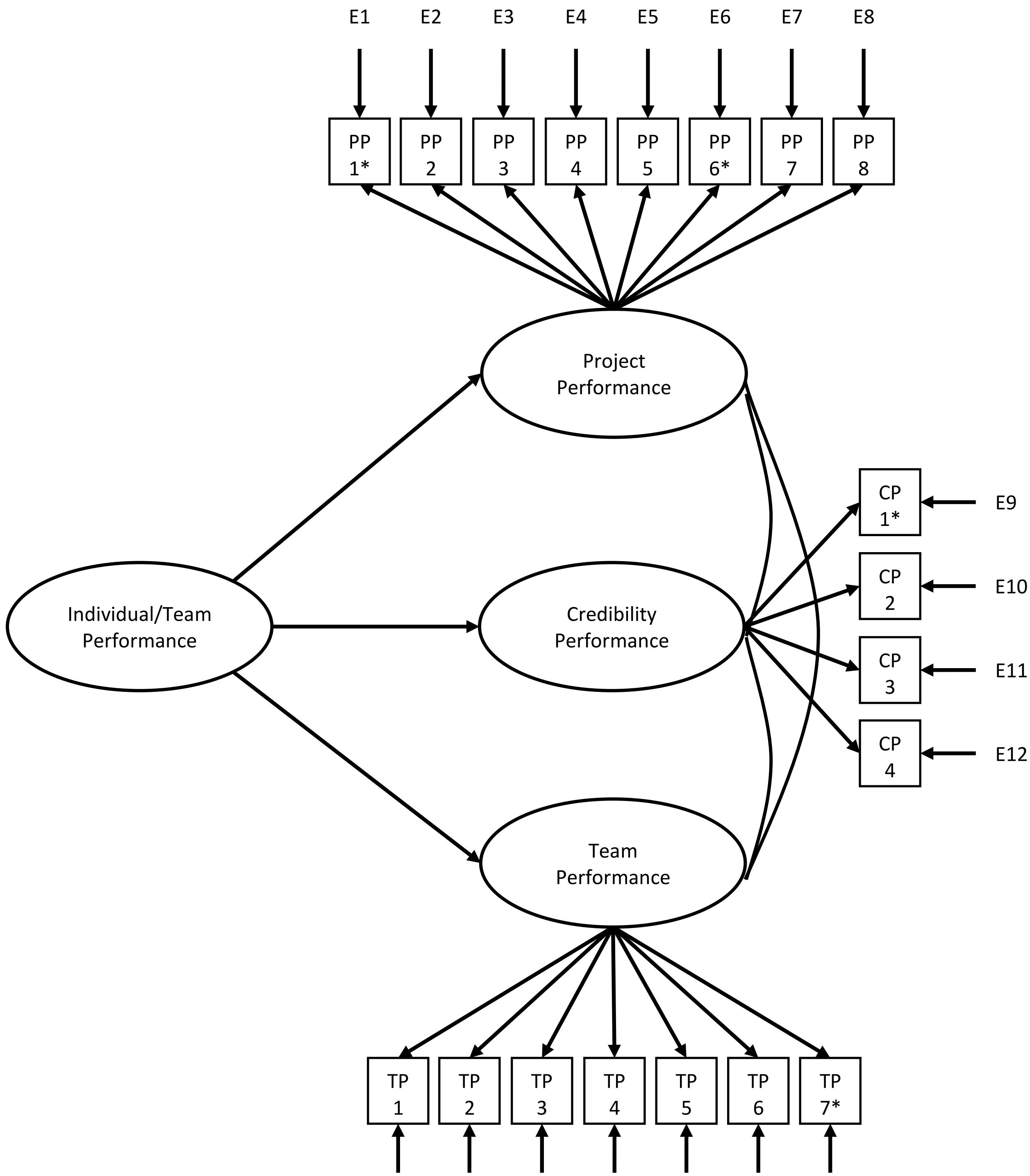


Figure 5-3: Factor Structure for the Individual/Team Performance Latent Variable; * Indicators with weak loadings or negative residual variances

Table 5-6: Factor Structure and Factor Loadings for Individual/Team Performance

Factor Structure	Higher-order CFA Factor Loadings (standardized estimates, p< .01)	CFA Sub-Factor Loadings (standardized estimates, p< .01)
Project Performance (PP)	0.70	
We adhered to schedule targets for the project (PP2).		0.62
We satisfied the scope of work for the project (PP3).		0.90
We accomplished our task for the project smoothly and efficiently (PP4).		0.83
We achieved project goals established by the project team (PP5).		0.76
We delivered a high-quality project for the owner (PP7).		0.56
The project was delivered safely without major safety incidents (PP8).		0.74
Communication Performance (CP)	0.74	
There was frequent communication within the team (CP2).		0.91
Team members communicated often in spontaneous meetings, phone conversations, etc. (CP3).		0.84
The team members largely communicated directly and personally with each other (CP4).		0.79
Team Performance (TP)	0.94	
All project team members were treated equally in the decision-making process (TP1).		0.76
All project team members worked with the same focus on project objectives (TP2).		0.81
We worked together to share information across organizational boundaries (TP3).		0.73
We worked towards mutually beneficial outcomes for all participants (TP4).		0.88
All project information was readily available to everyone involved in the project (TP5).		0.73
We always sought collective identification and resolution of problems (TP6).		0.65

The results of CFA demonstrated several weak indicators of *individual/team performance* being (PP1), (PP6), (CP1), and (TP7), as such were removed to improve model fit. The rest of the factors were retained at 0.05 level of significance and used in CFA to test the model fit. The standardized factor loadings and standard errors (S.E.) are given as [PP2 = 0.62

(0.10), PP3 = 0.90 (0.10), PP4 = 0.83 (0.09), PP5 = 0.76 (0.09), PP7 = 0.56 (0.10), PP8 = 0.74 (0.15), CP2 = 0.91 (0.10), CP3 = 0.84 (0.08), and CP4 = 0.79 (0.10), TP1 = 0.76 (0.09), TP2 = 0.81 (0.07), TP3 = 0.73 (0.06), TP4 = 0.88 (0.07), TP5 = 0.73 (0.07), and TP6 = 0.65 (0.10)]. The fit statistics for *individual/team performance* validates the reduced model fits the data (x^2 = 101.02, *df* = 87.0, *p* = 0.10, RMSEA = 0.06, CFI = 0.97). Detailed statistical analyses for latent variable shown in Figure 5-3 can be found in Appendix D.

Next, the correlations among all latent variables both higher-order latent variables and sub-factors are shown in Table 5-7. Factor scores generated from the measurement model were used to determine correlations among latent variables. Based on this table, all sub-factors are highly correlated with their higher-order factors. The composite reliability for each factor is also included in the table (see Appendix E and Appendix F for detailed statistical analyses for composite reliabilities).

Table 5-7: Correlations among Higher-order Latent Variables and Sub-factors

	Composite Reliability	*F1*	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*	*F8*	*F9*
1. Project Performance	0.83									
2. Communication Performance	0.82	0.61								
3. Team Performance	0.83	0.74	0.79							
4. Individual/Team Performance	0.84	0.80	0.85	0.99						
5. Coordination	0.77	0.63	0.74	0.79	0.81					
6. Credibility	0.83	0.55	0.77	0.81	0.82	0.88				
7. Specialization	0.50	0.53	0.78	0.77	0.79	0.82	0.87			
8. Transactive Memory System	0.90	0.60	0.80	0.83	0.84	0.94	0.98	0.93		
9. Goal Alignment	0.86	0.55	0.70	0.66	0.69	0.66	0.80	0.71	0.77	

Composite reliability was computed using nonlinear SEM reliability coefficient suggested by Green and Yang (2009). In this approach, polychoric correlations are estimated then followed by weighted least square estimation methods in Mplus. Once the model is fit, sample estimates for factor correlations, factor loadings, thresholds, and polychoric correlation are used as parameters to compute the nonlinear SEM reliability coefficient in SAS (Statistical Analysis Software) program (Green & Yang, 2009). Based on the table, several measures demonstrated good dimensionality and reliability (e.g., Project Performance, Communication Performance, Team Performance, Coordination, Credibility, and Goal Alignment). Meanwhile, the higher-order factors were estimated in SEM using each of the full measurement models (i.e., Individual/Team Performance and TMS).

5.3 Structural Equation Modeling (SEM)

This next step in SEM analysis is to inspect the unconditional and multilevel models. The unconditional model in Mplus did not show significant variation among case studies or levels of analyses in this study. In addition, SEM inclusive of all higher-order latent variables and sub-factors in the measurement model failed to converge due to sample size. As such, the researcher determined the data in this study was not hierarchical and continued the analyses using multiple regression/correlation analysis (MRC).

5.4 Multiple Regression/Correlation Analysis

MRC is a flexible statistical analysis approach when dealing with quantitative variables (Cohen et al., 2013). It is used to test the relationships between a dependent variable and multiple independent variables. As with any statistical analyses, several key assumptions must be considered prior to data analysis (Hair, Black, Babin, Anderson, & Tatham, 1998).

1. A linear relationship exists between the outcome variable and the independent variables.

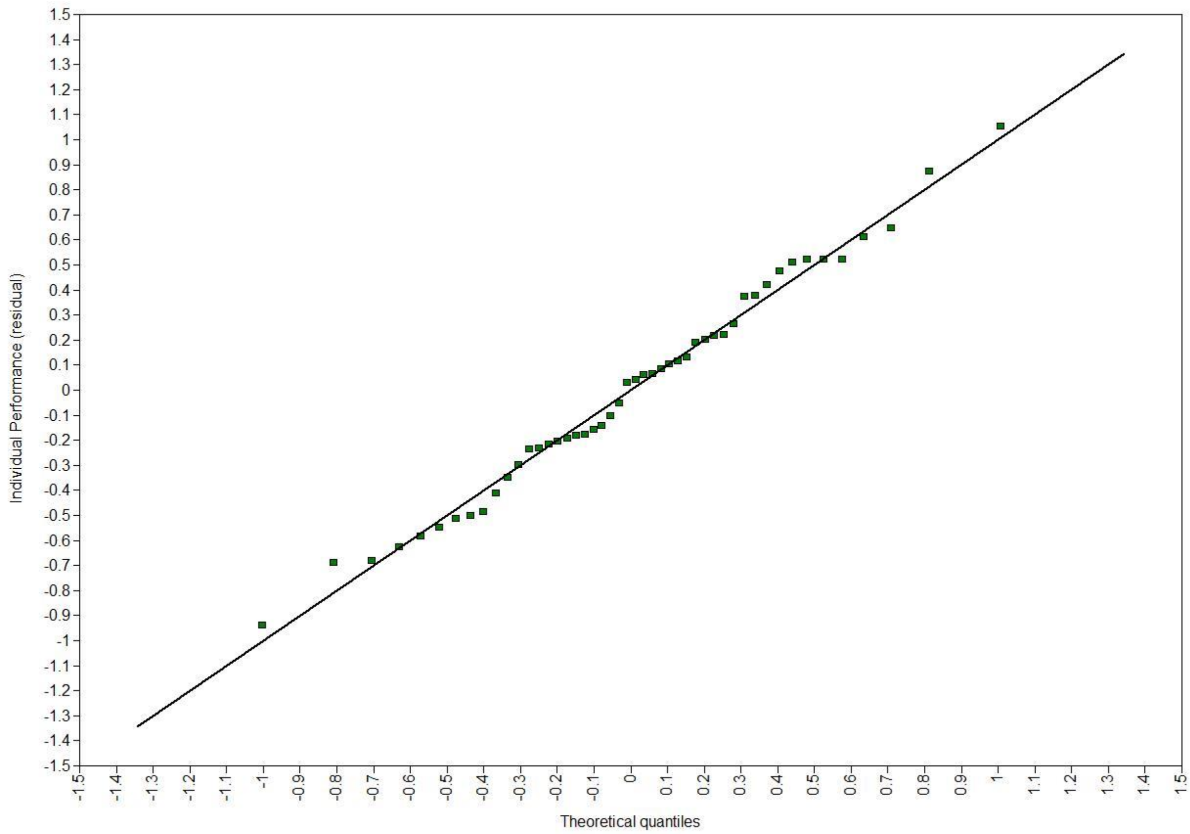
2. The residuals are normally distributed or multivariate normality.

3. Independent variables are not highly correlated with each other or multicollinearity.

4. The variance of error terms is similar across the values of independent variable or homoscedasticity.

The assumptions for linearity and normality are validated by evaluating the normality plot and histograms Figure 5-4 and Figure 5-5. In the normality plot shown in Figure 5-4, the data are linearly distributed. A good indication of linearity is the observation that data points are spread across the diagonal line. Figure 5-5 shows the histogram and distributions for the sample data. The data in this figure illustrate fairly good in terms of normal distribution. Last, Figure 5-6 plots estimates for *individual performance* (*x*-axis) against its residual terms (*y*-axis) to inspect for homoscedasticity. The observations show fairly good distribution above and below the zero point on the y-axis. The data in this study satisfied the assumptions and, thus, permitted the researcher the data using MRC.

Figure 5-4: P-P Plot for individual performance



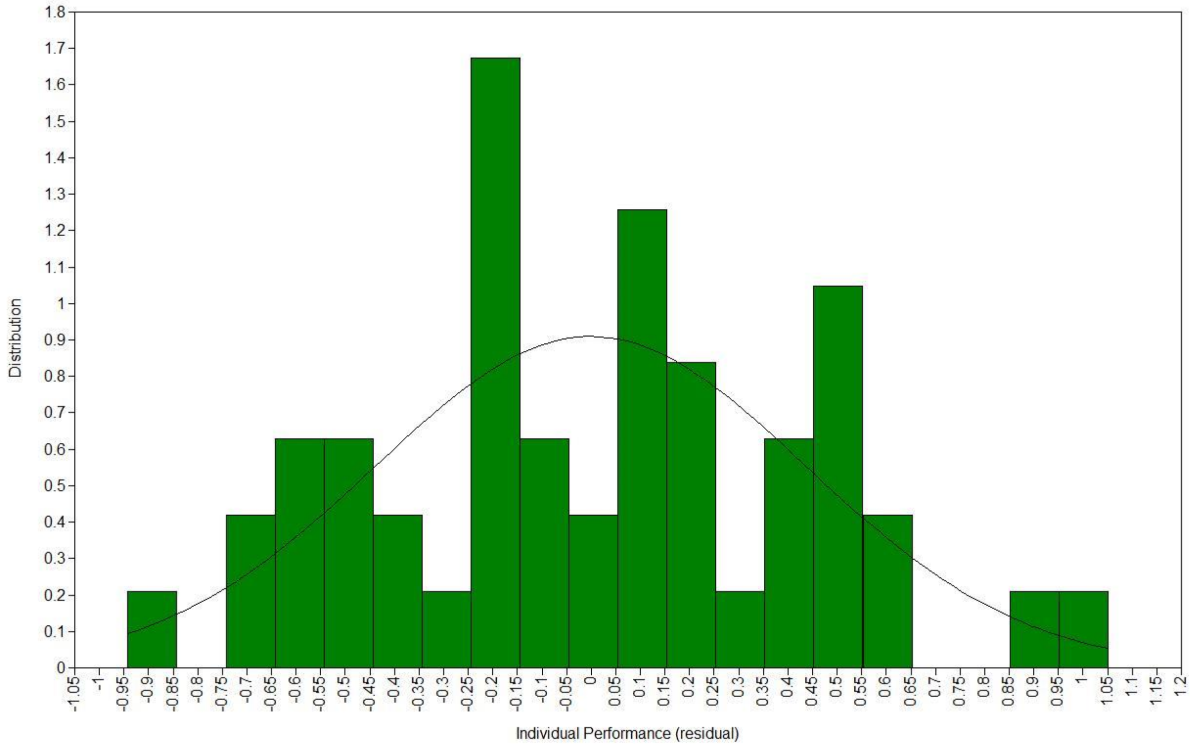


Figure 5-5: Histogram and distribution curve for individual performance

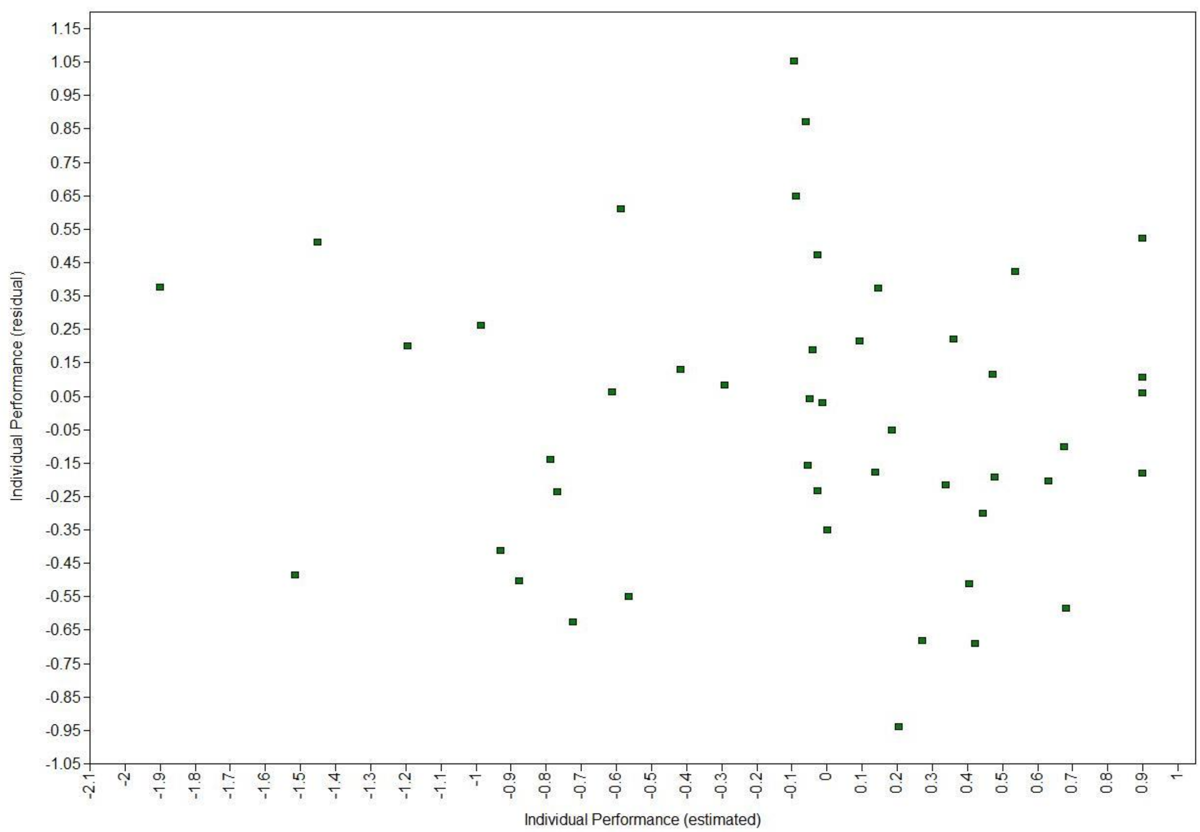


Figure 5-6: Residual plot of individual performance

The descriptive statistics for the survey data are given next in Table 5-4. These data were aggregated from survey responses across each second-order latent variable investigated in the model. These were used to represent a combined average value for higher-order latent variables in the model.

Table 5-8: Descriptive statistics for Goal Alignment, TMS, and Individual/Team Performance

	Goal Alignment	**TMS**	**Individual/Team Performance**
Mean*	4.70	4.36	4.21
Standard Error	0.06	0.06	0.08
Median*	4.80	4.50	4.29
Mode*	5.00	4.50	4.47
Standard Deviation	0.38	0.44	0.59
Sample Variance	0.15	0.20	0.35
Kurtosis	0.13	-0.06	-0.60
Skewness	-1.10	-0.80	-0.60
Range	1.40	1.70	2.16
Minimum	3.60	3.30	2.84
Maximum	5.00	5.00	5.00
Sum	225.60	209.10	202.05
Count**	48.00	48.00	48.00
Confidence Level (95.0%)	0.11	0.13	0.17

*Based on Likert Scale ranging from 5-Strongly agree to 1-Strongly disagree (**n=48); Average of all sub-factor scores

Results show relatively high mean ratings and low standard deviations across the sample respondents from the online survey (n=48) for the higher-order latent variables [i.e., *goal alignment* 4.70 (0.38), *TMS* 4.36 (0.44), and *Individual/team performance* 4.21 (0.59). In other words, little variation is present among respondent ratings based on the descriptive statistics.

The unconditional model was tested to assess whether a hierarchical structure exist for these data (i.e., only included level two or between group variable in the analysis). The equations below illustrate the unconditional model:

$$Individual/Team\ Performance\ =\ \beta_{0j} + e_{ij}$$

Where,

$$\beta_{0j}\ =\ \gamma_{00}$$

The results from this initial inspection found no significant variation at the between the level of analysis (i.e., 0.36 (0.25), *p*=0.15).

Tests at this juncture were conducted using computed factor scores from CFA attached to higher-order latent variables(Distefano, Zhu, & Mîndrilă, 2009). This "new" data must satisfy original statistical analyses assumptions. Particularly, test for skewness and non-normality. Factor scores in this study were imputed using CFA thus, are more stringently derived and hold against multiple fit indices. The higher-order latent variables were used to test the full model given in this study. The full model is shown below only examining level one (i.e., individual performance):

$$\begin{aligned} &Individual\ Performance \\ &\qquad = \gamma_{00} + \gamma_{01}(Mean\ SGA) + \gamma_{02}(Mean\ STMS)\ + \gamma_{10}(Individual\ GA)_i \\ &\qquad + \ \gamma_{20}(Individual\ TMS)_i + \ \gamma_{30}(IGA * ITMS)_i + e_i \end{aligned}$$

The researcher tested the full model using multivariate regression. The variables in this study explained 70 percent of the variance (i.e., Adjusted R Square = 0.70, $p < 0.001$) in *individual performance* perceptions for case study project team members. Of the four parameters in the model, one achieved significance at 0.001 (i.e., *TMS* r = 0.82, S.E. = 0.14, p = .000). The results are shown in Table 5-5. One of three hypotheses is supported as indicated below:

Hypothesis 1: *Individual performance in partnered-projects is directly related to individuals' goal alignment perception.* **(Not supported)**

Hypothesis 2: *Individuals' TMS moderates the relationship between individuals' goal alignment perceptions and individual/team performance in partnered-projects.* **(Not supported)**

Table 5-9: Descriptive statistics from multivariate regression analysis

Regression Statistics	
Multiple R	*0.85
R Square	*0.72
Adjusted R Square	*0.70
Standard Error	0.45
Observations	48

	df	*SS*	*MS*	*F*
Regression	3	22.90	7.63	37.034
Residual	44	9.07	0.21	
Total	47	31.97		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.05	0.08	0.64	0.528
Goal Alignment	0.11	0.15	0.69	0.493
Goal Alignment x TMS	0.01	0.12	0.07	0.947
TMS*	0.82	0.14	5.92	*0.000

*Significant $p < 0.001$

The results from CFA and MRC analyses demonstrate both utility and promise for both practitioners and researchers. The researcher identifies key attributes underlying *goal* *alignment*, *TMS*, and *individual performance*. Although only one of the latent constructs (i.e., *TMS*) was significant, this mild finding paves the way to continue exploring behavioral attributes during collaborative project delivery. A few practical and theoretical implications are listed next.

Practical Applications

- Practitioners should be cognizant during project delivery to the benefits of developing a clear system for coordination and communication in project teams. It is within this knowledge processing system where efficiency and trust are established.

Theoretical Implications

- Support for measures of *goal alignment* (Chan et al., 2004; Jap, 1999), *TMS* (Kyle Lewis, 2003; Zhang et al., 2015), and *individual performance* (Grajek et al., 2000; Gransberg et al., 1999; Hoegl & Gemuenden, 2001; J. S.-C. Hsu et al., 2012; Yeung et al., 2007) within AEC project teams.
- *Individuals' performance* perceptions are positively related to *transactive memory systems*
- Latent constructs in the model performed well in explaining the variance in *individual performance* perceptions. Future researchers may find these predictors useful to continue exploring relational governance structures that underlie collaborative project delivery practices.

5.5 Summary

Chapter 5 presented the quantitative analyses emanating from this study. Case study data demographics were given. Then, the researcher used confirmatory factor analysis to validate how well the hypothesized model fits the data. The chapter ends with hypothesis testing using multivariate regression analysis and reports its results. The next chapter summarizes the study findings and discusses practical and theoretical implications.

CHAPTER 6 DISCUSSIONS

This chapter summarizes key findings, discusses the practical application and theoretical contributions of this research. The chapter begins with qualitative findings from pattern-matching and cross-case synthesis. Next, quantitative findings captured from multivariate regression analysis are presented. This is followed by confirmatory factor analysis findings regarding the utility of study metrics used in quantitative data collection and analyses. The chapter, then, shifts giving a synopsis of key characteristics of individuals' and partnered projects'. Finally, theoretical implications and contributions are offered.

6.1.1 Qualitative Findings

In this section, the first objective was addressed based on qualitative findings. There were three propositions posited and validated using partnered project documents and structured interview data. The findings for each proposition are given below.

Proposition 1: *Project risk factors and the level of collaborative project delivery practices in partnered-projects are positively related.* **(Supported)**

The first proposition was supported in this study as evinced by pattern-matching and cross-case synthesis results. Using case study tactics, the researcher observed a clearly discernable pattern between project risk factors and collaborative project delivery practices. It was shown that four of six case studies successfully aligned their practices with project risk factors. When project risk was perceived as low, it became less important for collaborative project delivery practices to be aligned. However, two case studies (i.e. case studies #3 and #6) did not support this proposition.

As a result, these two cases offered a new proposition for future research.

Proposition 1a *- If collaborative project delivery practices are not positively aligned with the level of project risk in partnered-projects, then project performance will be negatively affected.*

The new proposition surfaced when holistically examining the structured interview data. In this, it becomes apparent that project performance is negatively affected when collaborative project delivery practices are not aligned with the level of project risk.

Proposition 2: *Collaborative project delivery practices and individuals' goal alignment perceptions in partnered-projects are positively related.* **(Limited Support)**

Findings from proposition 2 ostensibly did not support this proposition. Again, the researcher took a broader look not only on structured interview data but at the case study partnering documents. In doing so, an obvious pattern emerges when collaborative project delivery practices, goal alignment scores, and goal alignment actions are considered together. Goal alignment actions work in opposite directions. That is, higher collaborative project delivery practices constrained the need for project teams to use many goal alignment actions or metrics. The following proposition is offered as a result of this finding:

Proposition 2a *– Higher collaborative project delivery practices require fewer goal alignment actions or metrics to hold the project team accountable in partnered-projects.*

Proposition 3: *Individuals' goal alignment perception and project performance in partnered-projects are positively related.* **(Supported)**

The final proposition asserted in this study was also supported. This finding was exemplified when the researcher scrutinized case study partnering documents. Generally, when goal alignment is high project performance is also rated highly. One case study project was inconsistent in the results, and upon further inspection, the researcher discovered the top two projects followed similar performance metrics while the outlier (i.e., case study #6) did not. These two projects, specifically, included goal aligning performance metrics such as ensuring an integrated team response or teamwork was encouraged during problem-solving processes. Additionally, the top two projects sought continuous improvement by including a focal point around increased efficiencies in document management. Given the results, a new proposition developed:

Proposition 3a: *- Collaborative delivery practices should accommodate continuous improvement in facilitating information exchange among team members in partnered-projects.*

Considering the propositions above, strong support is demonstrated for the proposed framework posited in this study. In addition, three new propositions surfaced to which future research may consider. The quantitative aspects underpinning the first study objective are summarized next.

6.1.2 Quantitative Findings

This study sought to understand the relationship between *individual/team performance* and *goal alignment.* In addition, the researcher hypothesized a moderated effect existed among this relationship. The hypotheses were tested using partnered-project teams as a subset of collaboratively delivered projects. The results are recapitulated in this section along with the generalizability of findings.

Hypothesis 1: *Individual performance in partnered-projects is directly related to individuals' goal alignment perception.* **(Not supported)**

Results from hypothesis 1 did not support the theorized relationship posited. However, results from qualitative analysis help explain and triangulate these findings. The results may differ given a larger case study sampling where between level effects are more pronounced. Although individuals' performance perceptions were not related to goal alignment, project performance perceptions showed a clear relationship with TMS. This is explained in more detail at the end of this section.

Hypothesis 2: *Individuals' TMS moderates the relationship between individuals' goal alignment perceptions and individual/team performance in partnered-projects.* **(Not supported)**

Results for the theorized relationship in hypothesis 2 was not supported. In essence, little support was found in the data that TMS moderates the relationship between individuals' goal alignment and individual/team performance perceptions.

Table 6-1 displays descriptive statistics for the variables investigated in this study. The two hypotheses are useful for AEC projects following collaborative project delivery approaches, however, generalizing finding is cautioned. Partly, because the sample size is small across case studies and survey respondents (i.e., case studies = 6; N = 48). Despite this, the variables in this study explained 70 percent of the variance (i.e., Adjusted R Square = 0.70, $p < 0.001$) in *individual performance* perceptions for case study project team members. Of the four parameters in the model, one achieved significance at 0.001 (i.e., *TMS* $r = 0.82$, S.E. = 0.14, $p = .000$).

Table 6-1: Descriptive statistics for the relationship among study variables

Regression Statistics	
Multiple R	*0.85
R Square	*0.72
Adjusted R Square	*0.70
Standard Error	0.45
Observations	48

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.05	0.08	0.64	0.528
Goal Alignment	0.11	0.15	0.69	0.493
Goal Alignment x TMS	0.01	0.12	0.07	0.947
TMS*	0.82	0.14	5.92	*0.000

*Significant $p < 0.001$

6.1.3 Study Framework Finding Summarized

Taken together, the qualitative findings in this study offer a glimpse into the implications of goal alignment actions found in partnered-projects while quantitative findings begin to pinpoint a vital component for future investigation. The notion of goal alignment is seemingly innocuous, and many would quickly agree that effectively achieving multiple tasks (e.g. constructing a building) requires uniformity amongst the project team. However, research is still burgeoning as to why collaborative project delivery practices (Pishdad-Bozorgi & Beliveau, 2016) are a necessity conduit to bring about trust and goal congruence (Dietrich et al., 2010).

Correctly identifying the project risks serves multiple purposes. First, it helps project teams better prepare for transaction hazards such as ambiguity, volatility, uncertainty, and opportunism found during relational exchanges (Poppo & Zenger, 2002). The use of informal cues helps to marginalize these hazards during project delivery. For example, partnering workshops bring project teams together to address challenges in an open forum while continuously reminding them of their shared vision and goals for the project. It is within this environment where team members become more empowered to offer solutions when problems are encountered. The increases the level of trust and credibility within the team.

Second, it gives the owner and project team the ability to plan for some measure of uncertainty in advance. As an example, five of the case studies in this study included contingency dollars in the project while case study #6 never reported having any. Ironically, this case study project was noticeably impacted by unforeseen scope straining project resources (i.e., cost and time). Thus, the project performance suffered in this case study.

Even with contingencies, however, some case studies reported lower than anticipated performance ratings. This may have presented the opposite effect from the owners' perspective. Contingency may give rise to guarded optimism but can quickly change to a more conciliatory tone when change request becomes more frequent in projects. Change orders are then scrutinized from a lens of skepticism anticipating inflated pricing. This promotes mistrust and lowers individuals' perceptions of project performance even in light of hard metrics (e.g., actual cost and schedule data). Despite this, sharing common goals while managing and planning for project risks influences project performance outcomes. Next, a brief discussion on the utility of metrics utilized in data analysis is given.

6.2 Utility of Study Metrics

The second objective of this study was to provide empirical support for the quantitative metrics. Although goal alignment and TMS have received vast attention in organizational (Argote, 2015; Argote, Ingram, Levine, & Moreland, 2000; Stephen & Coote, 2007; Sundaramurthy & Lewis, 2003) and psychology (Hollingshead, 1998a; Park, Spitzmuller, &

DeShon, 2013; Wegner, 1987; Wegner et al., 1991) literature, these constructs are still rather novel in AEC literature (Cacamis & El Asmar, 2014; Comu et al., 2013; Suprapto et al., 2015; Zhang et al., 2015). Given this, this study used CFA to offer two metrics for future research. Meanwhile, a measure unique measure of individual performance was posited which moves beyond traditional cost and schedule performance metrics.

Findings from CFA confirm the constructs for goal alignment, TMS, individual performance are useful as a measurement model to assess team dynamics on partnered projects. The underlying indicators supporting each construct used in the analyses are given below in Tables 6-1 and 6-2. Standardized factor loadings, standard errors, and model fit statistics are also displayed in the tables.

Table 6-2: Findings from CFA for goal alignment and TMS

Latent Constructs and Factors	Standardized Factor Scores	Standard Errors
Goal Alignment (x^2 = 7.61, *df* = 5.0, *p* = 0.18, RMSEA = 0.10, CFI = 0.99)		
Mutual goals and objectives in the partnering charter were communicated effectively	0.79	0.08
Clear and compatible partnering goals were established by the project team	0.99	0.06
I generally agreed with project-related goals established by the project team	0.76	0.07
My attitude towards project-related goals established by the project team were similar	0.92	0.10
My goals for the project were in close alignment with the project team	0.78	0.11
TMS (x^2 = 23.62, *df* = 17.0, *p* = 0.13, RMSEA = 0.09, CFI = 0.99).		
Coordination		
The project team had very few misunderstandings about what to do during construction	0.94	0.08
I believe we accomplished our task for the project smoothly and efficiently	0.80	0.10
Credibility		
I was comfortable accepting procedural suggestions from other team members	0.66	0.12
I trusted that other members' knowledge about the project was credible	0.99	0.05
I was confident relying on the information that other team members brought to the discussion	0.92	0.04
Specialization		
I understand what skills my team members have and domains they are knowledgeable in	0.42	0.15
The specialized knowledge of several different team members was needed to complete the project	0.40	0.16
Overall, I am able to access other team member's thinking and knowledge	0.92	0.16

Table 6-3: Findings from CFA for individual performance

Latent Constructs and Factors	Standardized Factor Scores	Standard Errors
Individual Performance (x^2 = 101.02, *df* = 87.0, *p* = 0.10, RMSEA = 0.06, CFI = 0.97)		
Project Performance		
We adhered to schedule targets for the project	0.62	0.10
We satisfied the scope of work for the project	0.90	0.10
We accomplished our task for the project smoothly and efficient	0.83	0.09
We achieved project goals established by the project team	0.76	0.09
There was little rework required in this project	0.56	0.10
The project was delivered safely without major safety incidents	0.74	0.15
Communication Performance		
There was frequent communication within the team	0.91	0.10
Team members communicated often in spontaneous meetings, phone conversations, etc.	0.84	0.08
The team members largely communicated directly and personally with each other	0.79	0.10
Team Performance		
All project team members were treated equally in the decision-making process	0.76	0.09
All project team members worked with the same focus on project objectives	0.81	0.07
We worked together to share information across organizational boundaries	0.73	0.06
We worked towards mutually beneficial outcomes for all participants	0.88	0.07
All project information was readily available to everyone involved in the project	0.73	0.07
We always sought collective identification and resolution of problems	0.65	0.10

6.3 Key Characteristics of Individuals' and Partnered-Projects'

This study addressed the third objective by summarizing key attributes case study partnered projects hold in common. Additionally, this section presents the underlying commonalities of individuals' regarding project risk factors, collaborative project delivery practices, goal alignment, and project performance.

The data in this study used partnered projects as a subset of collaborative project delivery approaches typified in AEC literature (Rahman & Kumaraswamy, 2005; Suprapto et al., 2015; Xue et al., 2010). Several trends were identified that are consistent with other collaborative approaches. Partnered projects were consistently able to gain efficiencies in the areas of cost and schedule growth. This finding joins recent research which shows team integration and these common performance measures are related (Franz et al., 2016). There are other practical considerations from this study which are discussed next.

When project risks are relaxed collaborative project delivery practices are easily aligned. This finding showed up in proposition one. Based on this, it becomes clear that project risks such as teams with limited partnering experience or working on projects with high visibility required increased collaborative practices. These may offer early warnings if identified during the initial phase to engage in construction services. Proposition 1 also provided insight to incentives/disincentives.

Owners should avoid disincentives such as liquidated damages unless subsequent incentives or risk sharing arrangements are included in contracts (Meng, 2012). Performance should be equitable as to increase contractors' motivation to work collectively towards common goals and objectives. Otherwise, the informal attributes of flexibility, solidarity, and trust are eroded over time.

Proposition two posits that project teams should be cautious when many goal aligning actions surface during partnering workshops. This may serve as a leading indicator that project teams may be strained to align their individual goals with those outlined in the project charter.

This becomes problematic when performance is increased because complacency arises and individuals' may falsely attribute the success to the goal alignment actions taken (Sundaramurthy & Lewis, 2003). This is especially true when project risk is low and a limited number of collaborative practices are followed during project delivery.

Proposition three brought forth the notion that project teams should focus on a core set of goal alignment metrics that are detailed around a clear project objective. Particularly, they should avoid competing goal objectives within partnering charters as "no one can serve two masters." This internal conflict is a behavioral decision between the individual and team goals when some form of feedback (e.g., goal alignment objectives and actions identified in partnering charters) is present (DeShon et al., 2004).

Meanwhile, project teams should expect goal alignment to deviate over project life-cycle and should make provisions to continuously reinforce them. Again, helps prevent the team from falling into the self-perpetuating trap or cycles of collaboration that are destined for failure and become painfully obvious when project performance indicators drop (Sundaramurthy & Lewis, 2003). At this point, rigidity builds within the team and only exacerbates the problem to no end.

The next section covers the contributions of this study to the knowledge base and addresses its limitations.

6.4 Theoretical Contributions

Construction project owners have relied on traditional construction project delivery methods such as design-bid-build (DBB), construction management (CM), and design-build (DB) for years.

Though effective, many of these formal contracting practices work against collaboration and communication across organizations during the construction process. These approaches position owners' and contractors' behaviors towards transaction costs while attempting to deal with uncertainties involved in project delivery (Li et al., 2013; Ouchi, 1980).

Conversely, relational project delivery methodologies (e.g., Project Partnering, Strategic or Project Alliancing, and Integrated Project Delivery [IPD]) are bent on increasing levels of collaboration across organizations and to help mitigate risks (Lahdenperä, 2012). Relational governance theory which promotes norms of flexibility, solidarity and information exchange spurs these delivery approaches along (Poppo & Zenger, 2002). In this arrangement, economic safeguards found in traditional contracts are relaxed as individuals focus on trust to minimize opportunistic behaviors (Zaheer & Venkatraman, 1995).

This study challenged this dynamic with the research question centered on "*how goal alignment affects performance in AEC project teams when collaborative project delivery practices are followed*."

The motivation behind relational or collaborative project delivery approaches is to merge multi-disciplinary organizations into one cohesive unit. Removing cultural barriers requires strategies such as project team member consistency, colocation, and early involvement of all team members (e.g., prime contractors and specialty subcontractors) in decision-making (Baiden et al., 2003). Team integration strategies help project team members share information openly and honestly while tapping into a broad range of knowledge and expertise early on when decisions are less costly and more effective (Ospina-Alvarado et al., 2016). These distinct advantages comprised of experiences, mental models [i.e., an organized structure of shared knowledge among the team (Mohammed, & Dumville, 2001)], and motivation brings about goal alignment within project teams (Dietrich et al., 2010).

Departing from literature, early involvement of key participants (e.g., designer/contractor/specialty subcontractors) during schematic design did not appear significant in this study (Baiden et al., 2003; Cheng & Li, 2002; Pishdad-Bozorgi & Beliveau, 2016). Moreover, colocation, a common collaborative project delivery practice, was identified in only one case study despite tremendous benefits asserted in the literature (Baiden et al., 2003; Pishdad-Bozorgi & Beliveau, 2016). This is likely due to the constricted sampling of collaborative case study projects. The case studies were primarily public projects which have explicit design and preconstruction processes that are not conducive to early contractor involvement. Perhaps, a larger sample that includes both public and private projects can differentiate between the competing ideas.

Relational governance permeates these case studies (Carson et al., 2006; Ouchi, 1980; Williamson, 1979) as ample strategies were formally and informally codified in contract documents bent on flexibility, solidarity, and information exchanges to encourage trust. Not only did these project teams establish a relational governance structure, but feedback mechanisms (e.g., workshops, scorecards, and partnering meetings) were in place to encourage accountability. The benefits from feedback, benchmarking metrics, and conflict management strategies are to help project teams attain goal alignment. Goal congruence is increased especially during partnering workshops or partnering sessions where a neutral third-party facilitator is used to provide direct feedback on shared goals and objectives.

During partnering sessions, social loafing concerns may arise where project teams or members may take a backseat because the number of goal alignment actions becomes overwhelming (Lam, 2015). This problem is exacerbated as the number of project team members participating in workshops is increased. Thus, practitioners may find many participants are not fully committing to the partnering process resorting back to TCE theory focusing on individual goals.

Recent research points out existing paradoxes in the field of AEC project management and collaborative approaches as being generalized ideas that, when followed, do not always improve performance (Jacobsson & Roth, 2014). Conversely, this study uses case study evidence to guide and demonstrate a relationship between collaborative practices, goal alignment, and performance outcomes (Bresnen, 2007; Suprapto et al., 2015). In addition, it fills the gap in literature whereby behavioral underpinnings (i.e., goal alignment and TMS) are illuminated as key links between practices and performance.

6.5 Summary

To summarize, this section described the challenges and continued efforts the AEC industry balances aiming to improve project performance. Collaborative project delivery methods and approaches such as IPD and partnering are closing in on key informal attributes and mechanisms. The chapter summarizes findings from both quantitative and qualitative analysis followed in this study. Important characteristics emanating from the case study evidence is offered for researchers and practitioners. The chapter concludes by providing theoretical implications resulting from this research.

CHAPTER 7 CONCLUSIONS

Chapter 7 briefly summarizes research goals and objectives, research methods, findings, contributions to the body of knowledge. Then, the chapter finishes with limitations and suggestions for future research.

7.1 Summary of Research Goals and Objectives

The aim of this research was to systematically identify the underlying attributes of collaborative project delivery approaches which result in better performance. Focusing on partnered-projects as a type and subset of collaborative AEC project delivery approaches, the specific goals and objectives of this study were to:

1. Develop a framework demonstrating the relationship between project risk factors, collaborative project delivery practices, goal alignment, TMS, and performance outcomes by;
    a. Qualitatively examine the following at partnered-project level:
        i. The links among *project risk factors*, *collaborative project delivery practices*, and *project performance*.
    b. Quantitatively examine the following at individual and team level in interorganizational AEC project teams:
        i. The relationship between *individual/team performance*, *goal alignment,* and *TMS.*

2. Test an evaluation metric for *goal alignment* and utility of *TMS* metric to investigate AEC collaboration during project delivery;

3. Help facilitate collaborative contracting in construction projects by identifying key characteristics individuals' and projects' have in common.

4. Provide theoretical contributions to AEC literature understanding collaborative project delivery methodologies as a form of relational governance.

This study used empirical evidence via survey data, structured interviews, and case study project documents to support its goals and objectives. The researcher was able to satisfy these goals and objectives as shown presented in the summary of findings below.

7.2 Summary of Research Methods

A mixed-methods research approach was followed in this study building upon an emerging perspective to understand interorganizational project teams in AEC literature and analyze subsequent data (Korkmaz, 2007). The researcher initially asserted a multilevel or nested data structure with individuals embedded within teams (e.g., owner teams, design teams, and contractor teams) and teams are nested within case study projects. According to Yin (2003), multiple units of analysis offers greater flexibility to inspect data for consistent patterns across units and cases. A mixed-method approach enabled two types of data collection and data analysis methods (i.e., qualitative, quantitative). These data were used to integrate findings and draw inferences from a single study or theoretical perspective (Miller et al., 2011). Another advantage of mixed-methods is the ability to triangulate the findings of multiple forms of data, quantitative and qualitative (Campbell & Fiske, 1959).

Partnered case study project documents and structured interview data was collected and analyzed qualitatively. Pattern-matching was explored to investigate qualitative data which ostensibly provided case study characteristics and objective project performance findings. Next, cross-case synthesis was used to amalgamate findings from each case study and to illustrate support for or against the propositions put forth in this study.

Quantitative data was collected using an online survey and was analyzed using confirmatory factor analysis (CFA). CFA allowed the researcher to assess the measurement model against various model fit statistics. Next, SEM was conducted regarding the full measurement model. In doing so, limited support for multilevel data was found as such dependent variables in the findings are presented only for individual performance. The researcher continued with multivariate regression analyses to validate support for or against hypotheses asserted in this study.

7.3 Summary of Findings

The findings are presented against the five research goals and objectives.

1. Findings from proposition tested in this study were all adequately supported. Those propositions were: 1) *Project risk factors and the level of collaborative project delivery practices in partnered-projects are positively related;* 2) *Collaborative project delivery practices and individuals' goal alignment perceptions in partnered-projects are positively related; and,* 3) *Individuals' goal alignment perception and project performance in partnered-projects are positively related.*

a. Three new propositions were developed as a result of this study. Those propositions are: 1a) *If collaborative project delivery practices are not positively aligned with the level of project risk in partnered-projects, then project performance will be negatively affected*; 2a) *Higher collaborative project delivery practices require fewer goal alignment actions or metrics to hold the project team accountable in partnered-projects*; and, 3a) *Collaborative delivery practices should accommodate continuous improvement in facilitating information exchange among team members in partnered-projects.*

2. Findings from hypothesis testing demonstrated a relationship between *individual performance* and *transactive memory systems* (i.e., *TMS* $r = 0.82$, S.E. = 0.14, $p = .000$). The full multivariate model connecting *individual performance* to *goal alignment* and *transactive memory systems* was also supported (i.e., Adjusted $R^2 = 0.70$, $p < 0.001$). The variables in this study explained 70 percent of the variance (i.e., Adjusted R Square = 0.70) in *individual performance* perceptions for case study project team members.

3. Study metrics used in quantitative data collection and analysis are innovative in AEC research, thus this study provides validity and posits them for future research. The latent constructs and factors are shown in section 6.3.

4. Collaborative project delivery and its practices are furthered in this study. This was achieved by summarizing characteristics of individuals' and partnered projects' share. Some of these characteristics are positive while others should be changed to mitigate the impact on performance outcomes. For example, collaborative project delivery

practices found in partnering afforded case study project team's greater control over cost and schedule growth. Meanwhile, some other key attributes were:

a. Easier alignment of collaborative project delivery practices when project risk factors are relaxed;

b. Avoid disincentives such as liquidated damages unless subsequent incentives or risk sharing arrangements are included in contracts, otherwise gains in solidarity and trust are apt to suffer;

c. Focus on a core set of goal alignment metrics that are detailed around a clear project objective to minimize confusion and social loafing tendencies; and,

d. Expect goal alignment to deviate over project life-cycle and should make provisions to continuously reinforce them.

5. The next section details the contributions this research has made to the body of knowledge.

7.4 Contributions to the Body of Knowledge

There were several theoretical contributions this study made to the body of knowledge. These contributions are listed below.

1. Researchers over the years have alluded to cognitive behaviors and social norms as potential moderators between performance outcomes and collaborative project delivery approaches (Baiden et al., 2003; Baiden et al., 2006; Franz et al., 2016; A. Sparkling, 2014; Suprapto et al., 2015; Suprapto, Bakker, Mooi, & Moree, 2014). This

study takes a step further and posits clear metrics to understand behaviors *goal alignment* and team dynamics via *transactive memory systems*. Moreover, it offers an alternative approach to assess performance outcomes reaching beyond traditional cost, schedule, quality, and safety performance measures. It positioned a measurement model for *individual performance* which picks up on perceptions often masked in other hard performance metrics.

2. This study also directs attention to relational governance theory as explanatory for the unique dynamics research finds in team integration (Poppo & Zenger, 2002; Zaheer & Venkatraman, 1995). Collaborative project delivery approaches such as partnering and IPD find success by changing individuals' behaviors from opportunism. This shifts the foci from TCE theory where individuals are concerned with the costs of the exchange to one focused on solidarity, flexibility, and trust. Within the mindset, project teams are able to coalesce around shared project goals and objectives anticipating greater benefits than going at it alone.

3. This study also brings in social loafing theory (Lam, 2015) by taking into account the challenges of goal alignment. Maintaining goal alignment becomes problematic as the number of performance measures increases or when competing messages are sent. For instance, codifying disincentives in contracts without subsequent incentives or rewards works against goal congruence. In fact, it sends project team members backward toward opportunistic behaviors. Moreover, some may superficially acquiesce around collaborative project delivery practices rather than embrace the benefits (i.e., social loafing).

7.5 Limitations and Suggestions for Future Research

Despite all the findings and theoretical implications, this study does have limitations. Results were based on a limited number of survey respondents and a small case study sample (i.e., case studies = 6; N = 48). It is important to point out that 55% of the survey respondents represented the owner or owner's representative and other team members with owners' interests at hand (i.e., internal facilitators). In other words, the quantitative findings are heavily skewed towards their perceptions while 25% was that of the contractors and subcontractors. Another limitation of this study is that does not control for the other characteristics of these projects. As an example, the case studies were not representative of the U.S. as (2) were from the Midwest while (4) were located in the West. A similar issue is found with the project delivery approach followed among case studies. Of the six case studies, five used design-bid-build while only one utilized design-build. This partly offers an explanation for findings which suggest early contractor involvement departs from literature because this is a limitation of DBB.

Other study controls future researcher may consider are to include projects following varied project delivery approaches (e.g., traditional DBB, DB, partnering, and IPD), sizes, and locations. Findings from a larger data set may show disparate relationships than those found in this study. Additionally, a dataset comprised of more survey respondents may lend support for the additional direct (i.e., between *individual performance* and *goal alignment*) and moderated (i.e., *TMS* moderating *goal alignment and individual performance*) relationship suggested by the researcher. Further researchers may also find with a larger data set, unlike this study, a nested or multilevel data structure will allow for full SEM across various levels (e.g., case study projects, project teams, etc.).

As a final thought, this study finds it is important for researchers and practitioners to advance project-based collaboration as a means to improve the certainty of project performance outcomes. It used a mixed-methods approach to understand survey and case study data in its attempt to address this unique challenge. The contributions from this study are aimed to continue moving research towards stronger metrics to assess behavioral and social dynamics within AEC project teams. The will allow us to parse out core attributes inhibiting team integration and performance. Although this study did not support multilevel modeling, the AEC industry is replete with projects yearning for deeper analyses and inspect through this lens.

APPENDICES

APPENDIX A: Partnered-project Case Study Survey Instrument

MICHIGAN STATE UNIVERSITY

Consent for Participation

PURPOSE OF RESEARCH

This research study is part of a doctoral dissertation to investigate:

How goal alignment affects performance in Architecture, Engineering, and Construction (AEC) project teams when collaborative project delivery practices are followed on partnered-projects.

WHAT YOU WILL DO

Respond to survey questions via online survey. This should take about 10-12 minutes of your time.

PRIVACY AND CONFIDENTIALITY

Your confidentiality will be protected to the maximum extent allowable by law.
The researchers will not disclose any information about study participants' identities. Raw data collected will be only accessible by the research team and stored in password protected computers. Hard copies from collected data will be stored in a locked cabinet in the researchers' offices. The data will be stored for a minimum of three years after completion of the study. Only the appointed researchers and the Human Research Protection Program will have access to the research data. All data reporting will be presented in an aggregate or group format so no responses can be attributed to any individual. With these safeguards in place we request that you be candid and honest in providing your responses.

YOUR RIGHTS TO PARTICIPATE, OR WITHDRAW

Participation in this research is voluntary. You may choose not to answer specific questions or to stop participating at any time without penalty or loss of benefits to which you are otherwise entitled.

If you have questions or concerns about this study, such as scientific issues, how to do any part of it, or report any injuries please contact the principal investigator: Dr. Sinem Mollaoglu sinemm@msu.edu, 517-353-3252; or Anthony E. Sparkling (Investigator) sparkli1@msu.edu, 734-276-9826. For concerns regarding your role and rights as a research participant, to obtain information or offer input, or to register a complaint about this study, you may contact, anonymously, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or email irb@msu.edu or regular mail at: 4000 Collins Rd, Suite 136, Lansing, MI 48910.

You indicate your voluntary agreement to participate by completing this survey.

» Project Name

Background

NOTE: THIS SURVEY IS USED ACROSS MULTIPLE PROJECTS. PLEASE SPECIFY THE NAME OF YOUR PROJECT.

Project Name

What is your role in this project?

Owner or Owner's Representative

Stakeholder

Facilitator, please specify (i.e., third party, internal, Construction Manager, Owner team, etc.)

Designer/Engineer

Contractor

Subcontractor

Other, please specify

Goal Alignment

To help us understand how project team goals were aligned in this project (e.g., cost, schedule, quality, safety), please answer the following questions:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Mutual goals and objectives in the partnering charter were communicated effectively.	O	O	O	O	O
Clear and compatible project goals were established by the project team (e.g., cost, schedule, quality, safety performance).	O	O	O	O	O
I generally agreed with project-related goals established by the project team.	O	O	O	O	O
My attitude towards project-related goals established by the project team were similar.	O	O	O	O	O
My organizational goals for the project were in close alignment with the project team.	O	O	O	O	O

Transactive Memory System (TMS)

To help us understand if and how effectively information was coordinated and communicated in this project, please answer the following questions:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
The project team worked together in a well-coordinated fashion to complete the project.	O	O	O	O	O

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
The project team had very few misunderstandings about what to do during construction.	O	O	O	O	O
We accomplished our task for the project smoothly and efficiently.	O	O	O	O	O
I was comfortable accepting procedural suggestions from other project team members.	O	O	O	O	O
I trusted that other project team members' knowledge about the project was credible.	O	O	O	O	O
I was confident relying on the information that other project team members brought to the discussion.	O	O	O	O	O
When other project team members gave information, I wanted to double-check it for myself.	O	O	O	O	O
I understand what skills my team members have and domains they are knowledgeable in.	O	O	O	O	O
The specialized knowledge of several different team members was needed to complete the project.	O	O	O	O	O
Overall, I have been able to access other team member's thinking and knowledge.	O	O	O	O	O

Performance Outcomes

To help us understand project performance, please answer the following questions:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
We adhered to our organizational cost goals for the project.	O	O	O	O	O
We adhered to our organizational schedule targets for the project.	O	O	O	O	O
We satisfied our scope of work for the project.	O	O	O	O	O
We accomplished our task for the project smoothly and efficiently.	O	O	O	O	O
We achieved project goals established by the project team (e.g., cost and schedule targets).	O	O	O	O	O
We delivered a high quality project for the owner.	O	O	O	O	O
There was little rework required in this project.	O	O	O	O	O
The project was delivered safely without major safety incidents.	O	O	O	O	O

To help us understand communication performance , please answer the following questions:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
There was efficient and effective information sharing among the project team (e.g., RFI responses).	O	O	O	O	O
There was frequent communication within the team.	O	O	O	O	O
Team members communicated often in spontaneous meetings, phone conversations, etc.	O	O	O	O	O

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Team members largely communicated directly and personally with each other.	O	O	O	O	O

To help us understand team performance, please answer the following questions:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
All project team members were treated equally in the decision-making process.	O	O	O	O	O
All project team members worked with the same focus on project objectives.	O	O	O	O	O
We worked well together sharing information across organizational boundaries.	O	O	O	O	O
We worked towards mutually beneficial outcomes for all participants.	O	O	O	O	O
All project information was readily available to all project team members.	O	O	O	O	O
We always sought collective identification and resolution of problems using alternative dispute resolution practices (e.g., dispute resolution ladders, facilitated dispute resolution or special task force) .	O	O	O	O	O
Project team accountability was emphasized .	O	O	O	O	O

Comments

Please provide additional suggestions or comments to improve our understanding regarding team integration and collaboration in partnered-projects. For example, some argue team integration is best achieved when collaborative practices are incorporated in contracts.

If you would like to discuss this survey, please provide your contact information below:

APPENDIX B: Structured Interview Questions

CASE STUDY PARTNERED PROJECT PROFILE - STRUCTURED INTERVIEW QUESTIONS

Background Information

1) What is your role in this project?

Owner or Owner's Rep	☐	
Stakeholder	☐	
Facilitator, please specify (i.e., third party, internal, CM, Owner team, etc.)	☐	____________________
Designer/Engineer	☐	
Contractor	☐	
Subcontractor	☐	
Other, please specify	☐	____________________

2) Your Name: ____________________

3) Phone #: ____________________

4) Email: ____________________

Partnered Project Characteristics

5) What is the project type?

Vertical (e.g. commercial office buildings, schools, etc.)	☐	
Horizontal (e.g., highways, roadways, etc.)	☐	
Aviation	☐	
Large Infrastructure	☐	
Other, please specify	☐	____________________

6) What is the project location?

- West ☐
- East ☐
- Northeast ☐
- Mountain ☐
- Southwest ☐
- Southeast ☐
- Midwest ☐
- Other, please specify ☐ ______________________________

7) Is the project public or privately funded?

- Public ☐
- Private ☐

8) **The following questions are used to determine the <u>common risk factors</u> evaluated in partnering implementation decisions (Please indicate whether used in this project and rate level of importance):**						
		Not important=1 to Very important=5				
Number of project risks with potential impacts on cost/time (e.g., complex design and construction, public-private partnership, compressed schedule, uncommon materials, etc.)	☐ Few ☐ Moderate ☐ Many	1	2	3	4	5
Schedule risks with potential impacts on cost/time (e.g., liquidated damage and/or incentives)	☐ None ☐ Limited ☐ Many	1	2	3	4	5
Project team relationships	☐ Team has worked together before and has solid partnering foundation ☐ Team has no prior experience working together but has partnering foundation ☐ Team worked together before but no partnering foundation ☐ Team has not worked together and has no partnering foundation	1	2	3	4	5
Team partnering experience	☐ Experienced ☐ Some experience ☐ Most team members new to partnering	1	2	3	4	5
Political significance and community interest	☐ High visibility (significant strategic project) ☐ Probable (organization image at stake) ☐ Likely, depending on the size of the client and place of importance ☐ Unlikely, unless in a place of importance	1	2	3	4	5
Complexity	☐ High (i.e., highly technical and complex design and construction; short timeline/ schedule constraints, uncommon materials, new supply chain, etc.) ☐ Increased ☐ Moderate ☐ Standard	1	2	3	4	5
Project Delivery Method	☐ DBB ☐ DB ☐ CM/GC ☐ CMR ☐ Other	1	2	3	4	5

9) The following questions are used to determine the partnering collaboration level achieved in this project (Please indicate whether used in this project and rate level of importance):	Yes	No	Not important=1 to Very important=5				
Contractual Related Practices							
A professional facilitator was used in this project.	☐	☐	1	2	3	4	5
A shared equity arrangement was indicated in contracts.	☐	☐	1	2	3	4	5
A partnering charter was used in this project.	☐	☐	1	2	3	4	5
A proactive conflict management tool that added structure to collaborative problem solving processes was used in this project.	☐	☐	1	2	3	4	5
Equal power/empowerment was afforded to all project teams and team members in decision-making processes.	☐	☐	1	2	3	4	5
An incentive/fee/risk-reward/ or gainshare-painshare agreement was established in contracts.	☐	☐	1	2	3	4	5
Procurement Related Practices							
Parties were selected based on partnering experience.	☐	☐	1	2	3	4	5
We selected team members based on previous work experience with other team members.	☐	☐	1	2	3	4	5
Parties were selected based on technical expertise.	☐	☐	1	2	3	4	5
There was early involvement of key participants (e.g., designer/contractor/specialty subcontractors) during schematic design (SD).	☐	☐	1	2	3	4	5
Project Related Practices							
Partnering workshops were held for this project.	☐	☐	1	2	3	4	5
Partnering scorecards were used in this project.	☐	☐	1	2	3	4	5
There were two or more project teams located together in a common office (i.e., colocation).	☐	☐	1	2	3	4	5
Partnering training/team-building sessions were held for this project.	☐	☐	1	2	3	4	5
Measurable and achievable milestones were established to determine the success of the project.	☐	☐	1	2	3	4	5
Project teams openly exchanged information across organizational boundaries (e.g., Building Information Modeling (BIM))	☐	☐	1	2	3	4	5
Quarterly partnering meetings were used in this project.	☐	☐	1	2	3	4	5
Monthly partnering meetings were used in this project.	☐	☐	1	2	3	4	5
Multi-tiered partnering was used in this project (i.e., executive, core team, stakeholders)	☐	☐	1	2	3	4	5
Specific task force used for conflict and issue resolutions	☐	☐	1	2	3	4	5

Partnered Project Performance

10) The following questions are used to determine the cost performance associated with partnering implementation (Please indicate whether used in this project and rate level of satisfaction):					
Cost Growth	☐ Contract Project Cost: $____________ ☐ Actual Project Cost: $____________ (Indicate if values are estimated)				
Total Cost of Partnering	Facilitator, meetings expenses, surveys, etc.: $____________				
Estimated Savings Due to use of Partnering	Cost Savings as a % of Project Budget: %____________				
Owner's Satisfactions with the Cost Performance	**Not satisfied=1 to Very satisfied=5**				
	1	2	3	4	5

11) The following questions are used to determine the schedule performance associated with partnering implementation (Please indicate whether used in this project and rate level of satisfaction):						
Schedule Growth						*mm/dd/yy*
	Planned Start Date (Starting from Planning):					
	Planned Completion Date:					
	Planned # of Work Days (Construction): ___________					
	Actual Start Date (Notice to Proceed):					
	Actual Completion Date (Substantial Completion):					
	Actual # of Work Days (Construction): ____________					
Owner's Satisfactions with the Schedule Performance	**Not satisfied=1 to Very satisfied=5**					
	1	2	3	4	5	

12) The following questions are used to determine the quality and safety performance associated with partnering implementation (Please rate level of satisfaction):					
Owner's Satisfaction with the Quality Performance of this project	**Not satisfied=1 to Very satisfied=5**				
	1	2	3	4	5
Owner's Satisfaction with the Safety Performance of this project	**Not satisfied=1 to Very satisfied=5**				
	1	2	3	4	5

13) Please provide additional suggestions or comments to improve our understanding regarding team integration and collaboration in partnered-projects.

THANKS FOR TAKING YOUR TIME TO COMPLETE THE SURVEY!

APPENDIX C: Full Mplus Code and Output for Confirmatory Factor Analysis of Study Measurement Model

Mplus Code and Output for Confirmatory Factor Analysis of Measurement Model using Summed Scale Scores

INPUT INSTRUCTIONS

```
TITLE:      PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS FULL MODEL
DATA:        FILE IS Partnering Reduced4 Rev3.dat;
VARIABLE: NAMES ARE PROJ GA1-GA5 CO_SUM CO_AVE CR_SUM CR_AVE SP_SUM
     SP_AVE PP_SUM    PP_AVE CP_SUM CP_AVE TP_SUM   TP_AVE ROLE OWNER
     CONTR      OTHER;
     USEVARIABLES = GA1 GA3-GA5 CO_SUM CR_SUM SP_SUM PP_SUM CP_SUM TP_SUM;
     CATEGORICAL IS GA1 GA3-GA5;
MODEL:
  F4 BY PP_SUM* CP_SUM TP_SUM;
  F8 BY CO_SUM* CR_SUM SP_SUM;
  F9 BY GA1* GA3-GA5;
  F4@1;
  F8@1;
  F9@1;
  F4 WITH F8@.99;

OUTPUT:
  TECH1
```

INPUT READING TERMINATED NORMALLY

PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS FULL MODEL

SUMMARY OF ANALYSIS

Number of groups	1
Number of observations	48
Number of dependent variables	10
Number of independent variables	0
Number of continuous latent variables	3

Observed dependent variables

Continuous

CO_SUM CR_SUM SP_SUM PP_SUM CP_SUM TP_SUM

Binary and ordered categorical (ordinal)

GA1 GA3 GA4 GA5

Continuous latent variables

F4 F8 F9

Estimator	WLSMV
Maximum number of iterations	1000
Convergence criterion	0.500D-04
Maximum number of steepest descent iterations	20
Parameterization	DELTA
Link	PROBIT

Input data file(s)

Partnering Reduced4 Rev3.dat

Input data format FREE

UNIVARIATE PROPORTIONS AND COUNTS FOR CATEGORICAL VARIABLES

GA1

Category 1	0.021	1.000
Category 2	0.229	11.000
Category 3	0.750	36.000

GA3

Category 1	0.250	12.000
Category 2	0.750	36.000

GA4

Category 1	0.292	14.000
Category 2	0.708	34.000

GA5

Category 1	0.021	1.000
Category 2	0.354	17.000
Category 3	0.625	30.000

UNIVARIATE SAMPLE STATISTICS

UNIVARIATE HIGHER-ORDER MOMENT DESCRIPTIVE STATISTICS

Variable/	Mean/	Skewness/	Minimum/	% with	Percentiles		
Sample Size	Variance	Kurtosis	Maximum	Min/Max	20%/60%	40%/80%	Median

CO_SUM	8.417	-0.763	5.000	6.25%	7.000	8.000	9.000
	48.000	2.285	-0.377	10.000	31.25%	9.000	10.000
CR_SUM	13.375	-1.515	6.000	2.08%	12.000	13.000	14.000
	48.000	3.401	3.260	15.000	39.58%	14.000	15.000
SP_SUM	13.771	-0.838	10.000	2.08%	13.000	13.000	14.000
	48.000	1.510	0.250	15.000	37.50%	14.000	15.000
PP_SUM	23.521	-0.285	12.000	2.08%	18.000	21.000	24.000
	48.000	29.833	-1.119	30.000	29.17%	26.000	30.000
CP_SUM	13.833	-1.653	8.000	2.08%	12.000	14.000	15.000
	48.000	2.722	2.478	15.000	52.08%	15.000	15.000
TP_SUM	25.854	-0.836	17.000	2.08%	23.000	25.000	27.000
	48.000	12.500	-0.252	30.000	10.42%	28.000	29.000

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 30

Chi-Square Test of Model Fit

Value 38.458*

Degrees of Freedom 33

P-Value 0.2360

* The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used for chi-square difference testing in the regular way. MLM, MLR and WLSM chi-square difference testing is described on the Mplus website. MLMV, WLSMV, and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

Estimate	0.059	
90 Percent C.I.	0.000	0.126
Probability RMSEA <= .05	0.404	

CFI/TLI

CFI	0.974
TLI	0.965

Chi-Square Test of Model Fit for the Baseline Model

Value	256.302
Degrees of Freedom	45
P-Value	0.0000

WRMR (Weighted Root Mean Square Residual)

Value	0.457

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F4 BY				
PP_SUM	3.116	1.021	3.053	0.002
CP_SUM	1.113	0.246	4.520	0.000
TP_SUM	2.762	0.604	4.574	0.000

F8 BY

CO_SUM	1.030	0.258	3.986	0.000
CR_SUM	1.684	0.192	8.758	0.000
SP_SUM	0.726	0.169	4.292	0.000

F9 BY

GA1	0.625	0.108	5.798	0.000
GA3	0.847	0.074	11.434	0.000
GA4	0.933	0.071	13.235	0.000
GA5	0.800	0.081	9.906	0.000

F4 WITH

F8	0.990	0.000	999.000	999.000

F9 WITH

F4	0.908	0.058	15.711	0.000
F8	0.906	0.058	15.581	0.000

Intercepts

CO_SUM	8.417	0.273	30.884	0.000
CR_SUM	13.375	0.355	37.719	0.000
SP_SUM	13.771	0.214	64.410	0.000
PP_SUM	23.521	0.827	28.432	0.000
CP_SUM	13.833	0.382	36.256	0.000
TP_SUM	25.854	0.658	39.267	0.000

Thresholds

GA1$1	-2.037	0.411	-4.952	0.000
GA1$2	-0.674	0.197	-3.429	0.001
GA3$1	-0.674	0.197	-3.429	0.001
GA4$1	-0.549	0.191	-2.870	0.004
GA5$1	-2.037	0.411	-4.952	0.000
GA5$2	-0.319	0.184	-1.729	0.084

Variances

F4	1.000	0.000	999.000	999.000
F8	1.000	0.000	999.000	999.000
F9	1.000	0.000	999.000	999.000

Residual Variances

CO_SUM	1.224	0.257	4.768	0.000
CR_SUM	0.565	0.257	2.198	0.028
SP_SUM	0.983	0.204	4.815	0.000
PP_SUM	20.119	5.906	3.407	0.001
CP_SUM	1.484	0.323	4.599	0.000
TP_SUM	4.869	0.953	5.110	0.000

R-SQUARE

Observed Variable	Estimate	Residual Variance
GA1	0.391	0.609
GA3	0.717	0.283
GA4	0.871	0.129

GA5	0.640	0.360
CO_SUM	0.464	
CR_SUM	0.834	
SP_SUM	0.349	
PP_SUM	0.326	
CP_SUM	0.455	
TP_SUM	0.610	

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.343E-03

(ratio of smallest to largest eigenvalue)

TECHNICAL 1 OUTPUT

PARAMETER SPECIFICATION

TAU

GA1$1	GA1$2	GA3$1	GA4$1	GA5$1
1	2	3	4	5

TAU

GA5$2
6

NU

GA1	GA3	GA4	GA5	CO_SUM

0	0	0	0	7

NU

CR_SUM	SP_SUM	PP_SUM	CP_SUM	TP_SUM
8	9	10	11	12

LAMBDA

	F4	F8	F9
GA1	0	0	13
GA3	0	0	14
GA4	0	0	15
GA5	0	0	16
CO_SUM	0	17	0
CR_SUM	0	18	0
SP_SUM	0	19	0
PP_SUM	20	0	0
CP_SUM	21	0	0
TP_SUM	22	0	0

THETA

	GA1	GA3	GA4	GA5	CO_SUM
GA1	0				
GA3	0	0			
GA4	0	0	0		
GA5	0	0	0	0	

CO_SUM	0	0	0	0	23
CR_SUM	0	0	0	0	0
SP_SUM	0	0	0	0	0
PP_SUM	0	0	0	0	0
CP_SUM	0	0	0	0	0
TP_SUM	0	0	0	0	0

THETA

	CR_SUM	SP_SUM	PP_SUM	CP_SUM	TP_SUM
CR_SUM	24				
SP_SUM	0	25			
PP_SUM	0	0	26		
CP_SUM	0	0	0	27	
TP_SUM	0	0	0	0	28

ALPHA

F4	F8	F9
0	0	0

BETA

	F4	F8	F9
F4	0	0	0
F8	0	0	0
F9	0	0	0

PSI

	F4	F8	F9
F4	0		
F8	0	0	
F9	29	30	0

STARTING VALUES

TAU

GA1$1	GA1$2	GA3$1	GA4$1	GA5$1
-2.037	-0.674	-0.674	-0.549	-2.037

TAU

GA5$2
-0.319

NU

GA1	GA3	GA4	GA5	CO_SUM
0.000	0.000	0.000	0.000	8.417

NU

CR_SUM	SP_SUM	PP_SUM	CP_SUM	TP_SUM
13.375	13.771	23.521	13.833	25.854

LAMBDA

	F4	F8	F9
GA1	0.000	0.000	1.000
GA3	0.000	0.000	1.000
GA4	0.000	0.000	1.000
GA5	0.000	0.000	1.000
CO_SUM	0.000	1.000	0.000
CR_SUM	0.000	1.000	0.000
SP_SUM	0.000	1.000	0.000
PP_SUM	1.000	0.000	0.000
CP_SUM	1.000	0.000	0.000
TP_SUM	1.000	0.000	0.000

THETA

	GA1	GA3	GA4	GA5	CO_SUM
GA1	1.000				
GA3	0.000	1.000			
GA4	0.000	0.000	1.000		
GA5	0.000	0.000	0.000	1.000	
CO_SUM	0.000	0.000	0.000	0.000	1.142
CR_SUM	0.000	0.000	0.000	0.000	0.000
SP_SUM	0.000	0.000	0.000	0.000	0.000
PP_SUM	0.000	0.000	0.000	0.000	0.000
CP_SUM	0.000	0.000	0.000	0.000	0.000
TP_SUM	0.000	0.000	0.000	0.000	0.000

THETA

	CR_SUM	SP_SUM	PP_SUM	CP_SUM	TP_SUM
CR_SUM	1.701				
SP_SUM	0.000	0.755			
PP_SUM	0.000	0.000	14.916		
CP_SUM	0.000	0.000	0.000	1.361	
TP_SUM	0.000	0.000	0.000	0.000	6.250

ALPHA

F4	F8	F9
0.000	0.000	0.000

BETA

	F4	F8	F9
F4	0.000	0.000	0.000
F8	0.000	0.000	0.000
F9	0.000	0.000	0.000

PSI

	F4	F8	F9
F4	1.000		
F8	0.990	1.000	
F9	0.000	0.000	1.000

APPENDIX D: Full Mplus Code and Output for Confirmatory Factor Analysis of Study Latent Variables

Mplus Code and Output for Confirmatory Factor Analysis of Goal Alignment

```
INPUT INSTRUCTIONS
    TITLE:    PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS GOAL ALIGNMENT
    DATA:     FILE IS Partnering Reduced4 Rev1.dat;
    VARIABLE:     NAMES ARE PROJ GA1-GA5 CO1-CO3 CR1-CR4 SP1-SP3 PP1-PP8
         CP1-CP4 TP1-TP7 ROLE OWNER CONT OTHER;
         USEVARIABLES = GA1-GA5;
         CATEGORICAL IS GA1-GA5;
    MODEL:
       F9 BY GA1* GA2 GA3 GA4 GA5;
       F9@1;

INPUT READING TERMINATED NORMALLY
PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS GOAL ALIGNMENT
SUMMARY OF ANALYSIS
Number of groups                          1
Number of observations                    48
Number of dependent variables             5
Number of independent variables           0
Number of continuous latent variables     1

Observed dependent variables
  Binary and ordered categorical (ordinal)
   GA1     GA2     GA3     GA4     GA5
```

Continuous latent variables

F9

Estimator WLSMV

Maximum number of iterations 1000

Convergence criterion 0.500D-04

Maximum number of steepest descent iterations 20

Parameterization DELTA

Link PROBIT

Input data file(s)

Partnering Reduced4 Rev1.dat

Input data format FREE

UNIVARIATE PROPORTIONS AND COUNTS FOR CATEGORICAL VARIABLES

GA1		
Category 1	0.021	1.000
Category 2	0.229	11.000
Category 3	0.750	36.000
GA2		
Category 1	0.042	2.000
Category 2	0.208	10.000
Category 3	0.750	36.000
GA3		
Category 1	0.250	12.000

Category 2	0.750	36.000
GA4		
Category 1	0.292	14.000
Category 2	0.708	34.000
GA5		
Category 1	0.021	1.000
Category 2	0.354	17.000
Category 3	0.625	30.000

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 13

Chi-Square Test of Model Fit

Value	7.612*
Degrees of Freedom	5
P-Value	0.1790

* The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used for chi-square difference testing in the regular way. MLM, MLR and WLSM chi-square difference testing is described on the Mplus website. MLMV, WLSMV, and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

Estimate	0.104	
90 Percent C.I.	0.000	0.244
Probability RMSEA <= .05		0.236

CFI/TLI

CFI	0.992
TLI	0.984

Chi-Square Test of Model Fit for the Baseline Model

Value	327.961
Degrees of Freedom	10
P-Value	0.0000

WRMR (Weighted Root Mean Square Residual)

Value	0.499

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F9 BY				
GA1	0.791	0.080	9.881	0.000
GA2	0.986	0.060	16.300	0.000
GA3	0.764	0.069	11.093	0.000
GA4	0.920	0.098	9.436	0.000
GA5	0.782	0.113	6.896	0.000
Thresholds				
GA1$1	-2.037	0.411	-4.952	0.000
GA1$2	-0.674	0.197	-3.429	0.001
GA2$1	-1.732	0.324	-5.348	0.000
GA2$2	-0.674	0.197	-3.429	0.001

GA3$1	-0.674	0.197	-3.429	0.001
GA4$1	-0.549	0.191	-2.870	0.004
GA5$1	-2.037	0.411	-4.952	0.000
GA5$2	-0.319	0.184	-1.729	0.084

Variances

F9	1.000	0.000	999.000	999.000

R-SQUARE

Observed Variable	Estimate	Residual Variance
GA1	0.626	0.374
GA2	0.972	0.028
GA3	0.583	0.417
GA4	0.847	0.153
GA5	0.612	0.388

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.121E-01

(ratio of smallest to largest eigenvalue)

Mplus Code and Output for Confirmatory Factor Analysis of TMS

INPUT INSTRUCTIONS

```
TITLE:   PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS TMS
DATA:    FILE IS Partnering Reduced4 Rev1.dat;
VARIABLE:    NAMES ARE PROJ GA1-GA5 CO1-CO3 CR1-CR4 SP1-SP3 PP1-PP8
    CP1-CP4 TP1-TP7 ROLE OWNER CONT OTHER;
    USEVARIABLES = CO2-CO3 CR1-CR3 SP1-SP3;
    CATEGORICAL IS CO2-CO3 CR1-CR3 SP1-SP3;
MODEL:
 F5 BY CO2* CO3;
 F6 BY CR1* CR2 CR3;
 F7 BY SP1* SP2 SP3;
 F5@1;
 F6@1;
 F7@1;
```

INPUT READING TERMINATED NORMALLY

PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS TMS

SUMMARY OF ANALYSIS

Number of groups	1
Number of observations	48
Number of dependent variables	8
Number of independent variables	0
Number of continuous latent variables	3

Observed dependent variables

Binary and ordered categorical (ordinal)

CO2 CO3 CR1 CR2 CR3 SP1

SP2 SP3

Continuous latent variables

F5 F6 F7

Estimator WLSMV

Maximum number of iterations 1000

Convergence criterion 0.500D-04

Maximum number of steepest descent iterations 20

Parameterization DELTA

Link PROBIT

Input data file(s)

Partnering Reduced4 Rev1.dat

Input data format FREE

UNIVARIATE PROPORTIONS AND COUNTS FOR CATEGORICAL VARIABLES

CO2

Category 1	0.125	6.000
Category 2	0.042	2.000
Category 3	0.417	20.000
Category 4	0.417	20.000

CO3

Category 1	0.146	7.000

Category 2	0.417	20.000
Category 3	0.438	21.000
CR1		
Category 1	0.021	1.000
Category 2	0.042	2.000
Category 3	0.271	13.000
Category 4	0.667	32.000
CR2		
Category 1	0.042	2.000
Category 2	0.042	2.000
Category 3	0.375	18.000
Category 4	0.542	26.000
CR3		
Category 1	0.021	1.000
Category 2	0.062	3.000
Category 3	0.417	20.000
Category 4	0.500	24.000
SP1		
Category 1	0.042	2.000
Category 2	0.375	18.000
Category 3	0.583	28.000
SP2		
Category 1	0.021	1.000
Category 2	0.208	10.000
Category 3	0.771	37.000
SP3		
Category 1	0.083	4.000

Category 2 0.333 16.000

Category 3 0.583 28.000

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 31

Chi-Square Test of Model Fit

Value 23.618*

Degrees of Freedom 17

P-Value 0.1302

* The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used for chi-square difference testing in the regular way. MLM, MLR and WLSM chi-square difference testing is described on the Mplus website. MLMV, WLSMV, and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

Estimate 0.090

90 Percent C.I. 0.000 0.170

Probability RMSEA <= .05 0.222

CFI/TLI

CFI 0.986

TLI 0.977

Chi-Square Test of Model Fit for the Baseline Model

Value 509.782

Degrees of Freedom 28

P-Value 0.0000

WRMR (Weighted Root Mean Square Residual)

Value 0.515

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F5 BY				
CO2	0.939	0.081	11.618	0.000
CO3	0.804	0.099	8.104	0.000
F6 BY				
CR1	0.664	0.120	5.523	0.000
CR2	0.990	0.045	22.220	0.000
CR3	0.915	0.044	20.798	0.000
F7 BY				
SP1	0.419	0.147	2.845	0.004
SP2	0.399	0.155	2.583	0.010
SP3	0.923	0.157	5.861	0.000
F6 WITH				
F5	0.790	0.101	7.838	0.000

F7 WITH

F5	0.715	0.147	4.865	0.000
F6	0.761	0.145	5.236	0.000

Thresholds

CO2$1	-1.150	0.232	-4.961	0.000
CO2$2	-0.967	0.215	-4.493	0.000
CO2$3	0.210	0.182	1.154	0.249
CO3$1	-1.054	0.223	-4.736	0.000
CO3$2	0.157	0.182	0.866	0.387
CR1$1	-2.037	0.411	-4.952	0.000
CR1$2	-1.534	0.284	-5.400	0.000
CR1$3	-0.431	0.187	-2.302	0.021
CR2$1	-1.732	0.324	-5.348	0.000
CR2$2	-1.383	0.260	-5.315	0.000
CR2$3	-0.105	0.181	-0.577	0.564
CR3$1	-2.037	0.411	-4.952	0.000
CR3$2	-1.383	0.260	-5.315	0.000
CR3$3	0.000	0.181	0.000	1.000
SP1$1	-1.732	0.324	-5.348	0.000
SP1$2	-0.210	0.182	-1.154	0.249
SP2$1	-2.037	0.411	-4.952	0.000
SP2$2	-0.742	0.200	-3.704	0.000
SP3$1	-1.383	0.260	-5.315	0.000
SP3$2	-0.210	0.182	-1.154	0.249

Variances

F5	1.000	0.000	999.000	999.000
F6	1.000	0.000	999.000	999.000
F7	1.000	0.000	999.000	999.000

R-SQUARE

Observed Variable	Estimate	Residual Variance
CO2	0.882	0.118
CO3	0.646	0.354
CR1	0.441	0.559
CR2	0.981	0.019
CR3	0.838	0.162
SP1	0.176	0.824
SP2	0.159	0.841
SP3	0.852	0.148

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.547E-02

(ratio of smallest to largest eigenvalue)

Mplus Code and Output for Confirmatory Factor Analysis of Individual/Team Performance

INPUT INSTRUCTIONS

```
TITLE:    PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS PERFORMANCE
DATA:     FILE IS Partnering Reduced4 Rev1.dat;
VARIABLE: NAMES ARE PROJ GA1-GA5 CO1-CO3 CR1-CR4 SP1-SP3 PP1-PP8
          CP1-CP4 TP1-TP7 ROLE OWNER CONT OTHER;
          USEVARIABLES = PP2-PP5 PP7 PP8 CP2-CP4 TP1-TP6;
          CATEGORICAL IS PP2-PP5 PP7 PP8 CP2-CP4 TP1-TP6;
MODEL:
  F1 BY PP2* PP3 PP4 PP5 PP7 PP8;
  F2 BY CP2* CP3 CP4;
  F3 BY TP1* TP2 TP3 TP4 TP5 TP6;
  F1@1;
  F2@1;
  F3@1;
```

INPUT READING TERMINATED NORMALLY

PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS PERFORMANCE

SUMMARY OF ANALYSIS

Number of groups	1
Number of observations	48
Number of dependent variables	15
Number of independent variables	0
Number of continuous latent variables	3

Observed dependent variables

Binary and ordered categorical (ordinal)

PP2	PP3	PP4	PP5	PP7	PP8
CP2	CP3	CP4	TP1	TP2	TP3
TP4	TP5	TP6			

Continuous latent variables

F1 F2 F3

Estimator WLSMV

Maximum number of iterations 1000

Convergence criterion 0.500D-04

Maximum number of steepest descent iterations 20

Parameterization DELTA

Link PROBIT

Input data file(s)

Partnering Reduced4 Rev1.dat

Input data format FREE

UNIVARIATE PROPORTIONS AND COUNTS FOR CATEGORICAL VARIABLES

PP2

Category 1	0.042	2.000
Category 2	0.208	10.000
Category 3	0.146	7.000
Category 4	0.042	2.000
Category 5	0.562	27.000

PP3		
Category 1	0.188	9.000
Category 2	0.042	2.000
Category 3	0.771	37.000
PP4		
Category 1	0.396	19.000
Category 2	0.104	5.000
Category 3	0.021	1.000
Category 4	0.479	23.000
PP5		
Category 1	0.021	1.000
Category 2	0.396	19.000
Category 3	0.104	5.000
Category 4	0.479	23.000
PP7		
Category 1	0.021	1.000
Category 2	0.271	13.000
Category 3	0.167	8.000
Category 4	0.062	3.000
Category 5	0.479	23.000
PP8		
Category 1	0.167	8.000
Category 2	0.021	1.000
Category 3	0.812	39.000
CP2		
Category 1	0.021	1.000
Category 2	0.208	10.000

Category 3	0.771	37.000
CP3		
Category 1	0.042	2.000
Category 2	0.250	12.000
Category 3	0.708	34.000
CP4		
Category 1	0.042	2.000
Category 2	0.042	2.000
Category 3	0.312	15.000
Category 4	0.604	29.000
TP1		
Category 1	0.062	3.000
Category 2	0.167	8.000
Category 3	0.479	23.000
Category 4	0.292	14.000
TP2		
Category 1	0.021	1.000
Category 2	0.042	2.000
Category 3	0.042	2.000
Category 4	0.396	19.000
Category 5	0.500	24.000
TP3		
Category 1	0.042	2.000
Category 2	0.083	4.000
Category 3	0.333	16.000
Category 4	0.542	26.000
TP4		

Category 1	0.021	1.000
Category 2	0.062	3.000
Category 3	0.312	15.000
Category 4	0.604	29.000
TP5		
Category 1	0.042	2.000
Category 2	0.083	4.000
Category 3	0.312	15.000
Category 4	0.562	27.000
TP6		
Category 1	0.188	9.000
Category 2	0.354	17.000
Category 3	0.458	22.000

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 61

Chi-Square Test of Model Fit

Value 104.016*

Degrees of Freedom 87

P-Value 0.1031

* The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used for chi-square difference testing in the regular way. MLM, MLR and WLSM chi-square difference testing is described on the Mplus website. MLMV, WLSMV, and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

Estimate	0.064
90 Percent C.I.	0.000 0.106
Probability RMSEA <= .05	0.313

CFI/TLI

CFI	0.972
TLI	0.966

Chi-Square Test of Model Fit for the Baseline Model

Value	702.098
Degrees of Freedom	105
P-Value	0.0000

WRMR (Weighted Root Mean Square Residual)

Value	0.706

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F1 BY				
PP2	0.623	0.104	5.979	0.000
PP3	0.904	0.103	8.736	0.000
PP4	0.832	0.088	9.446	0.000
PP5	0.745	0.086	8.629	0.000
PP7	0.559	0.099	5.676	0.000
PP8	0.737	0.148	4.982	0.000

F2 BY				
CP2	0.914	0.100	9.126	0.000
CP3	0.838	0.083	10.113	0.000
CP4	0.785	0.104	7.573	0.000
F3 BY				
TP1	0.763	0.091	8.358	0.000
TP2	0.805	0.068	11.806	0.000
TP3	0.734	0.062	11.912	0.000
TP4	0.876	0.069	12.776	0.000
TP5	0.732	0.069	10.585	0.000
TP6	0.645	0.098	6.577	0.000
F2 WITH				
F1	0.517	0.126	4.097	0.000
F3 WITH				
F1	0.652	0.111	5.860	0.000
F2	0.695	0.086	8.050	0.000
Thresholds				
PP2$1	-1.732	0.324	-5.348	0.000
PP2$2	-0.674	0.197	-3.429	0.001
PP2$3	-0.264	0.183	-1.442	0.149
PP2$4	-0.157	0.182	-0.866	0.387
PP3$1	-0.887	0.209	-4.239	0.000

PP3$2	-0.742	0.200	-3.704	0.000
PP4$1	-0.264	0.183	-1.442	0.149
PP4$2	0.000	0.181	0.000	1.000
PP4$3	0.052	0.181	0.289	0.773
PP5$1	-2.037	0.411	-4.952	0.000
PP5$2	-0.210	0.182	-1.154	0.249
PP5$3	0.052	0.181	0.289	0.773
PP7$1	-2.037	0.411	-4.952	0.000
PP7$2	-0.549	0.191	-2.870	0.004
PP7$3	-0.105	0.181	-0.577	0.564
PP7$4	0.052	0.181	0.289	0.773
PP8$1	-0.967	0.215	-4.493	0.000
PP8$2	-0.887	0.209	-4.239	0.000
CP2$1	-2.037	0.411	-4.952	0.000
CP2$2	-0.742	0.200	-3.704	0.000
CP3$1	-1.732	0.324	-5.348	0.000
CP3$2	-0.549	0.191	-2.870	0.004
CP4$1	-1.732	0.324	-5.348	0.000
CP4$2	-1.383	0.260	-5.315	0.000
CP4$3	-0.264	0.183	-1.442	0.149
TP1$1	-1.534	0.284	-5.400	0.000
TP1$2	-0.742	0.200	-3.704	0.000
TP1$3	0.549	0.191	2.870	0.004
TP2$1	-2.037	0.411	-4.952	0.000
TP2$2	-1.534	0.284	-5.400	0.000
TP2$3	-1.258	0.244	-5.159	0.000
TP2$4	0.000	0.181	0.000	1.000

TP3$1	-1.732	0.324	-5.348	0.000
TP3$2	-1.150	0.232	-4.961	0.000
TP3$3	-0.105	0.181	-0.577	0.564
TP4$1	-2.037	0.411	-4.952	0.000
TP4$2	-1.383	0.260	-5.315	0.000
TP4$3	-0.264	0.183	-1.442	0.149
TP5$1	-1.732	0.324	-5.348	0.000
TP5$2	-1.150	0.232	-4.961	0.000
TP5$3	-0.157	0.182	-0.866	0.387
TP6$1	-0.887	0.209	-4.239	0.000
TP6$2	0.105	0.181	0.577	0.564

Variances

F1	1.000	0.000	999.000	999.000
F2	1.000	0.000	999.000	999.000
F3	1.000	0.000	999.000	999.000

R-SQUARE

Observed Variable	Estimate	Residual Variance
PP2	0.388	0.612
PP3	0.817	0.183
PP4	0.692	0.308
PP5	0.555	0.445
PP7	0.313	0.687
PP8	0.544	0.456

CP2	0.835	0.165
CP3	0.703	0.297
CP4	0.617	0.383
TP1	0.582	0.418
TP2	0.648	0.352
TP3	0.539	0.461
TP4	0.768	0.232
TP5	0.536	0.464
TP6	0.417	0.583

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.596E-02

(ratio of smallest to largest eigenvalue)

APPENDIX E: Full Mplus Code and Output for SEM Reliability of Latent Variables

Mplus Input Code and Output for SEM Reliability of Study Latent Variable TMS

INPUT INSTRUCTIONS

```
    TITLE:      PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS TMS
    DATA:         FILE IS Partnering Reduced4 Rev1.dat;
    VARIABLE:           NAMES ARE PROJ GA1-GA5 CO1-CO3 CR1-CR4 SP1-SP3 PP1-PP8
          CP1-CP4 TP1-TP7 ROLE OWNER CONT OTHER;
          USEVARIABLES = CO2-CO3 CR1-CR3 SP1-SP3;
          CATEGORICAL IS CO2-CO3 CR1-CR3 SP1-SP3;
    MODEL:
     F5 BY CO2 CO3;
     F6 BY CR1 CR2 CR3;
     F7 BY SP1 SP2 SP3;
     F5@1;
     F6@1;
     F7@1;
     F8 BY F5* (P1)
        F6 F7 (P2-P3);
        F5-F7 (P4-P6);
     F8@1;

    MODEL CONSTRAINT:
     NEW(COMP_REL);
         COMP_REL =(P1+P2+P3)**2/
         ((P1+P2+P3)**2+P4+P5+P6);
    OUTPUT: CINTERVAL;
```

INPUT READING TERMINATED NORMALLY

PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS TMS

SUMMARY OF ANALYSIS

Number of groups 1

Number of observations 48

Number of dependent variables 8

Number of independent variables 0

Number of continuous latent variables 4

Observed dependent variables

Binary and ordered categorical (ordinal)

CO2 CO3 CR1 CR2 CR3 SP1

SP2 SP3

Continuous latent variables

F5 F6 F7 F8

Estimator WLSMV

Maximum number of iterations 1000

Convergence criterion 0.500D-04

Maximum number of steepest descent iterations 20

Parameterization DELTA

Link PROBIT

Input data file(s)

Partnering Reduced4 Rev1.dat

Input data format FREE

UNIVARIATE PROPORTIONS AND COUNTS FOR CATEGORICAL VARIABLES

CO2		
Category 1	0.125	6.000
Category 2	0.042	2.000
Category 3	0.417	20.000
Category 4	0.417	20.000
CO3		
Category 1	0.146	7.000
Category 2	0.417	20.000
Category 3	0.438	21.000
CR1		
Category 1	0.021	1.000
Category 2	0.042	2.000
Category 3	0.271	13.000
Category 4	0.667	32.000
CR2		
Category 1	0.042	2.000
Category 2	0.042	2.000
Category 3	0.375	18.000
Category 4	0.542	26.000
CR3		
Category 1	0.021	1.000
Category 2	0.062	3.000
Category 3	0.417	20.000
Category 4	0.500	24.000

SP1		
Category 1	0.042	2.000
Category 2	0.375	18.000
Category 3	0.583	28.000
SP2		
Category 1	0.021	1.000
Category 2	0.208	10.000
Category 3	0.771	37.000
SP3		
Category 1	0.083	4.000
Category 2	0.333	16.000
Category 3	0.583	28.000

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 31

Chi-Square Test of Model Fit

Value 23.618*

Degrees of Freedom 17

P-Value 0.1302

* The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used for chi-square difference testing in the regular way. MLM, MLR and WLSM chi-square difference testing is described on the Mplus website. MLMV, WLSMV, and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

Estimate	0.090
90 Percent C.I.	0.000 0.170
Probability RMSEA <= .05	0.222

CFI/TLI

CFI	0.986
TLI	0.977

Chi-Square Test of Model Fit for the Baseline Model

Value	509.782
Degrees of Freedom	28
P-Value	0.0000

WRMR (Weighted Root Mean Square Residual)

Value	0.515

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F5 BY				
CO2	1.000	0.000	999.000	999.000
CO3	0.855	0.130	6.575	0.000
F6 BY				
CR1	1.000	0.000	999.000	999.000

CR2	1.491	0.266	5.607	0.000
CR3	1.378	0.251	5.497	0.000

F7 BY

SP1	1.000	0.000	999.000	999.000
SP2	0.952	0.529	1.800	0.072
SP3	2.202	0.851	2.587	0.010

F8 BY

F5	0.810	0.091	8.859	0.000
F6	0.609	0.111	5.469	0.000
F7	0.348	0.138	2.519	0.012

Thresholds

CO2$1	-1.150	0.232	-4.961	0.000
CO2$2	-0.967	0.215	-4.493	0.000
CO2$3	0.210	0.182	1.154	0.249
CO3$1	-1.054	0.223	-4.736	0.000
CO3$2	0.157	0.182	0.866	0.387
CR1$1	-2.037	0.411	-4.952	0.000
CR1$2	-1.534	0.284	-5.400	0.000
CR1$3	-0.431	0.187	-2.302	0.021
CR2$1	-1.732	0.324	-5.348	0.000
CR2$2	-1.383	0.260	-5.315	0.000
CR2$3	-0.105	0.181	-0.577	0.564
CR3$1	-2.037	0.411	-4.952	0.000
CR3$2	-1.383	0.260	-5.315	0.000

CR3$3	0.000	0.181	0.000	1.000
SP1$1	-1.732	0.324	-5.348	0.000
SP1$2	-0.210	0.182	-1.154	0.249
SP2$1	-2.037	0.411	-4.952	0.000
SP2$2	-0.742	0.200	-3.704	0.000
SP3$1	-1.383	0.260	-5.315	0.000
SP3$2	-0.210	0.182	-1.154	0.249

Variances

F8	1.000	0.000	999.000	999.000

Residual Variances

F5	0.227	0.176	1.286	0.198
F6	0.070	0.076	0.921	0.357
F7	0.055	0.054	1.005	0.315

New/Additional Parameters

COMP_REL	0.899	0.053	17.008	0.000

R-SQUARE

Observed Variable	Estimate	Residual Variance
CO2	0.882	0.118
CO3	0.646	0.354
CR1	0.441	0.559
CR2	0.981	0.019

CR3	0.838	0.162
SP1	0.176	0.824
SP2	0.159	0.841
SP3	0.852	0.148

Latent Variable	Estimate
F5	0.743
F6	0.841
F7	0.688

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.532E-03

(ratio of smallest to largest eigenvalue)

CONFIDENCE INTERVALS OF MODEL RESULTS

	Lower .5%	Lower 2.5%	Lower 5%	Estimate	Upper 5%	Upper 2.5%	Upper .5%
F5 BY							
CO2	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CO3	0.520	0.600	0.641	0.855	1.069	1.110	1.191
F6 BY							
CR1	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CR2	0.806	0.969	1.053	1.491	1.928	2.012	2.175
CR3	0.732	0.886	0.965	1.378	1.790	1.869	2.023

F7 BY

SP1	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SP2	-0.410	-0.085	0.082	0.952	1.822	1.989	2.315
SP3	0.010	0.534	0.802	2.202	3.601	3.869	4.393

F8 BY

F5	0.574	0.631	0.659	0.810	0.960	0.989	1.045
F6	0.322	0.391	0.426	0.609	0.792	0.828	0.896
F7	-0.008	0.077	0.121	0.348	0.575	0.618	0.703

Thresholds

CO2$1	-1.748	-1.605	-1.532	-1.150	-0.769	-0.696	-0.553
CO2$2	-1.522	-1.389	-1.322	-0.967	-0.613	-0.545	-0.413
CO2$3	-0.259	-0.147	-0.090	0.210	0.510	0.568	0.680
CO3$1	-1.628	-1.491	-1.421	-1.054	-0.688	-0.618	-0.481
CO3$2	-0.311	-0.199	-0.142	0.157	0.456	0.513	0.625
CR1$1	-3.096	-2.843	-2.713	-2.037	-1.360	-1.231	-0.977
CR1$2	-2.266	-2.091	-2.001	-1.534	-1.067	-0.977	-0.802
CR1$3	-0.913	-0.798	-0.739	-0.431	-0.123	-0.064	0.051
CR2$1	-2.566	-2.366	-2.264	-1.732	-1.199	-1.097	-0.898
CR2$2	-2.053	-1.893	-1.811	-1.383	-0.955	-0.873	-0.713
CR2$3	-0.572	-0.460	-0.403	-0.105	0.194	0.251	0.362
CR3$1	-3.096	-2.843	-2.713	-2.037	-1.360	-1.231	-0.977
CR3$2	-2.053	-1.893	-1.811	-1.383	-0.955	-0.873	-0.713
CR3$3	-0.466	-0.355	-0.298	0.000	0.298	0.355	0.466
SP1$1	-2.566	-2.366	-2.264	-1.732	-1.199	-1.097	-0.898
SP1$2	-0.680	-0.568	-0.510	-0.210	0.090	0.147	0.259

SP2\$1	-3.096	-2.843	-2.713	-2.037	-1.360	-1.231	-0.977
SP2\$2	-1.257	-1.134	-1.071	-0.742	-0.412	-0.349	-0.226
SP3\$1	-2.053	-1.893	-1.811	-1.383	-0.955	-0.873	-0.713
SP3\$2	-0.680	-0.568	-0.510	-0.210	0.090	0.147	0.259

Variances

F8	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Residual Variances

F5	-0.227	-0.119	-0.063	0.227	0.517	0.572	0.681
F6	-0.126	-0.079	-0.055	0.070	0.196	0.220	0.267
F7	-0.086	-0.052	-0.035	0.055	0.144	0.161	0.195

New/Additional Parameters

COMP_REL	0.763	0.795	0.812	0.899	0.986	1.002	1.035

Mplus Input Code and Output for SEM Reliability of Study Latent Variable Individual/Team Performance

INPUT INSTRUCTIONS

```
TITLE:      PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS PERFORMANCE

DATA:        FILE IS Partnering Reduced4 Rev1.dat;

VARIABLE: NAMES ARE PROJ GA1-GA5 CO1-CO3 CR1-CR4 SP1-SP3 PP1-PP8

     CP1-CP4 TP1-TP7 ROLE OWNER CONT OTHER;

     USEVARIABLES = PP2-PP5 PP7 PP8 CP2-CP4 TP1-TP6;

     CATEGORICAL IS PP2-PP5 PP7 PP8 CP2-CP4 TP1-TP6;

MODEL:

  F1 BY PP2 PP3 PP4 PP5 PP7 PP8;

  F2 BY CP2 CP3 CP4;

  F3 BY TP1 TP2 TP3 TP4 TP5 TP6;

      F1@1;

  F2@1;

  F3@1;

  F4 BY F1* (P1)

     F2 F3 (P2-P3);

     F1-F3 (P4-P6);

  F4@1;


MODEL CONSTRAINT:

  NEW(COMP_REL);

      COMP_REL =(P1+P2+P3)**2/

      ((P1+P2+P3)**2+P4+P5+P6);

OUTPUT: CINTERVAL;
```

INPUT READING TERMINATED NORMALLY

PARTNERING DATA CONFIRMATORY FACTOR ANALYSIS PERFORMANCE

SUMMARY OF ANALYSIS

Number of groups	1
Number of observations	48
Number of dependent variables	15
Number of independent variables	0
Number of continuous latent variables	4

Observed dependent variables

Binary and ordered categorical (ordinal)

PP2	PP3	PP4	PP5	PP7	PP8
CP2	CP3	CP4	TP1	TP2	TP3
TP4	TP5	TP6			

Continuous latent variables

F1 F2 F3 F4

Estimator	WLSMV
Maximum number of iterations	1000
Convergence criterion	0.500D-04
Maximum number of steepest descent iterations	20
Parameterization	DELTA
Link	PROBIT

Input data file(s)

Partnering Reduced4 Rev1.dat

Input data format FREE

UNIVARIATE PROPORTIONS AND COUNTS FOR CATEGORICAL VARIABLES

PP2

Category 1	0.042	2.000
Category 2	0.208	10.000
Category 3	0.146	7.000
Category 4	0.042	2.000
Category 5	0.562	27.000

PP3

Category 1	0.188	9.000
Category 2	0.042	2.000
Category 3	0.771	37.000

PP4

Category 1	0.396	19.000
Category 2	0.104	5.000
Category 3	0.021	1.000
Category 4	0.479	23.000

PP5

Category 1	0.021	1.000
Category 2	0.396	19.000
Category 3	0.104	5.000
Category 4	0.479	23.000

PP7

Category 1	0.021	1.000
Category 2	0.271	13.000

Category 3	0.167	8.000
Category 4	0.062	3.000
Category 5	0.479	23.000
PP8		
Category 1	0.167	8.000
Category 2	0.021	1.000
Category 3	0.812	39.000
CP2		
Category 1	0.021	1.000
Category 2	0.208	10.000
Category 3	0.771	37.000
CP3		
Category 1	0.042	2.000
Category 2	0.250	12.000
Category 3	0.708	34.000
CP4		
Category 1	0.042	2.000
Category 2	0.042	2.000
Category 3	0.312	15.000
Category 4	0.604	29.000
TP1		
Category 1	0.062	3.000
Category 2	0.167	8.000
Category 3	0.479	23.000
Category 4	0.292	14.000
TP2		
Category 1	0.021	1.000

Category 2	0.042	2.000
Category 3	0.042	2.000
Category 4	0.396	19.000
Category 5	0.500	24.000
TP3		
Category 1	0.042	2.000
Category 2	0.083	4.000
Category 3	0.333	16.000
Category 4	0.542	26.000
TP4		
Category 1	0.021	1.000
Category 2	0.062	3.000
Category 3	0.312	15.000
Category 4	0.604	29.000
TP5		
Category 1	0.042	2.000
Category 2	0.083	4.000
Category 3	0.312	15.000
Category 4	0.562	27.000
TP6		
Category 1	0.188	9.000
Category 2	0.354	17.000
Category 3	0.458	22.000

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 61

Chi-Square Test of Model Fit

Value	104.016*
Degrees of Freedom	87
P-Value	0.1031

* The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used for chi-square difference testing in the regular way. MLM, MLR and WLSM chi-square difference testing is described on the Mplus website. MLMV, WLSMV, and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

Estimate	0.064
90 Percent C.I.	0.000 0.106
Probability RMSEA <= .05	0.313

CFI/TLI

CFI	0.972
TLI	0.966

Chi-Square Test of Model Fit for the Baseline Model

Value	702.098
Degrees of Freedom	105
P-Value	0.0000

WRMR (Weighted Root Mean Square Residual)

Value 0.706

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F1 BY				
PP2	1.000	0.000	999.000	999.000
PP3	1.451	0.280	5.182	0.000
PP4	1.335	0.279	4.785	0.000
PP5	1.196	0.230	5.209	0.000
PP7	0.898	0.210	4.274	0.000
PP8	1.184	0.262	4.509	0.000
F2 BY				
CP2	1.000	0.000	999.000	999.000
CP3	0.917	0.154	5.955	0.000
CP4	0.859	0.171	5.026	0.000
F3 BY				
TP1	1.000	0.000	999.000	999.000
TP2	1.055	0.170	6.187	0.000
TP3	0.962	0.163	5.902	0.000
TP4	1.148	0.150	7.659	0.000
TP5	0.959	0.122	7.834	0.000
TP6	0.846	0.150	5.646	0.000

F4 BY

F1	0.434	0.104	4.162	0.000
F2	0.678	0.134	5.050	0.000
F3	0.715	0.108	6.642	0.000

Thresholds

PP2$1	-1.732	0.324	-5.348	0.000
PP2$2	-0.674	0.197	-3.429	0.001
PP2$3	-0.264	0.183	-1.442	0.149
PP2$4	-0.157	0.182	-0.866	0.387
PP3$1	-0.887	0.209	-4.239	0.000
PP3$2	-0.742	0.200	-3.704	0.000
PP4$1	-0.264	0.183	-1.442	0.149
PP4$2	0.000	0.181	0.000	1.000
PP4$3	0.052	0.181	0.289	0.773
PP5$1	-2.037	0.411	-4.952	0.000
PP5$2	-0.210	0.182	-1.154	0.249
PP5$3	0.052	0.181	0.289	0.773
PP7$1	-2.037	0.411	-4.952	0.000
PP7$2	-0.549	0.191	-2.870	0.004
PP7$3	-0.105	0.181	-0.577	0.564
PP7$4	0.052	0.181	0.289	0.773
PP8$1	-0.967	0.215	-4.493	0.000
PP8$2	-0.887	0.209	-4.239	0.000
CP2$1	-2.037	0.411	-4.952	0.000
CP2$2	-0.742	0.200	-3.704	0.000
CP3$1	-1.732	0.324	-5.348	0.000

CP3$2	-0.549	0.191	-2.870	0.004
CP4$1	-1.732	0.324	-5.348	0.000
CP4$2	-1.383	0.260	-5.315	0.000
CP4$3	-0.264	0.183	-1.442	0.149
TP1$1	-1.534	0.284	-5.400	0.000
TP1$2	-0.742	0.200	-3.704	0.000
TP1$3	0.549	0.191	2.870	0.004
TP2$1	-2.037	0.411	-4.952	0.000
TP2$2	-1.534	0.284	-5.400	0.000
TP2$3	-1.258	0.244	-5.159	0.000
TP2$4	0.000	0.181	0.000	1.000
TP3$1	-1.732	0.324	-5.348	0.000
TP3$2	-1.150	0.232	-4.961	0.000
TP3$3	-0.105	0.181	-0.577	0.564
TP4$1	-2.037	0.411	-4.952	0.000
TP4$2	-1.383	0.260	-5.315	0.000
TP4$3	-0.264	0.183	-1.442	0.149
TP5$1	-1.732	0.324	-5.348	0.000
TP5$2	-1.150	0.232	-4.961	0.000
TP5$3	-0.157	0.182	-0.866	0.387
TP6$1	-0.887	0.209	-4.239	0.000
TP6$2	0.105	0.181	0.577	0.564

Variances

F4	1.000	0.000	999.000	999.000

Residual Variances

F1	0.200	0.089	2.247	0.025
F2	0.375	0.146	2.575	0.010
F3	0.072	0.115	0.626	0.531

New/Additional Parameters

COMP_REL	0.838	0.045	18.483	0.000

R-SQUARE

Observed Variable	Estimate	Residual Variance
PP2	0.388	0.612
PP3	0.817	0.183
PP4	0.692	0.308
PP5	0.555	0.445
PP7	0.313	0.687
PP8	0.544	0.456
CP2	0.835	0.165
CP3	0.703	0.297
CP4	0.617	0.383
TP1	0.582	0.418
TP2	0.648	0.352
TP3	0.539	0.461
TP4	0.768	0.232
TP5	0.536	0.464
TP6	0.417	0.583

Latent Variable	Estimate
F1	0.485
F2	0.551
F3	0.877

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.946E-03

(ratio of smallest to largest eigenvalue)

CONFIDENCE INTERVALS OF MODEL RESULTS

	Lower .5%	Lower 2.5%	Lower 5%	Estimate	Upper 5%	Upper 2.5%	Upper .5%
F1 BY							
PP2	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PP3	0.730	0.902	0.990	1.451	1.912	2.000	2.172
PP4	0.616	0.788	0.876	1.335	1.794	1.882	2.054
PP5	0.605	0.746	0.818	1.196	1.574	1.646	1.788
PP7	0.357	0.486	0.552	0.898	1.243	1.309	1.438
PP8	0.507	0.669	0.752	1.184	1.615	1.698	1.860
F2 BY							
CP2	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CP3	0.521	0.615	0.664	0.917	1.171	1.219	1.314
CP4	0.419	0.524	0.578	0.859	1.141	1.195	1.300
F3 BY							

TP1	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TP2	0.616	0.721	0.774	1.055	1.335	1.389	1.494
TP3	0.542	0.643	0.694	0.962	1.231	1.282	1.382
TP4	0.762	0.854	0.902	1.148	1.395	1.442	1.534
TP5	0.644	0.719	0.758	0.959	1.160	1.199	1.274
TP6	0.460	0.552	0.599	0.846	1.092	1.139	1.232

F4 BY

F1	0.165	0.230	0.262	0.434	0.606	0.638	0.703
F2	0.332	0.415	0.457	0.678	0.899	0.942	1.024
F3	0.437	0.504	0.538	0.715	0.892	0.925	0.992

Thresholds

PP2$1	-2.566	-2.366	-2.264	-1.732	-1.199	-1.097	-0.898
PP2$2	-1.181	-1.060	-0.998	-0.674	-0.351	-0.289	-0.168
PP2$3	-0.736	-0.623	-0.566	-0.264	0.037	0.095	0.208
PP2$4	-0.625	-0.513	-0.456	-0.157	0.142	0.199	0.311
PP3$1	-1.426	-1.297	-1.231	-0.887	-0.543	-0.477	-0.348
PP3$2	-1.257	-1.134	-1.071	-0.742	-0.412	-0.349	-0.226
PP4$1	-0.736	-0.623	-0.566	-0.264	0.037	0.095	0.208
PP4$2	-0.466	-0.355	-0.298	0.000	0.298	0.355	0.466
PP4$3	-0.414	-0.302	-0.245	0.052	0.350	0.407	0.518
PP5$1	-3.096	-2.843	-2.713	-2.037	-1.360	-1.231	-0.977
PP5$2	-0.680	-0.568	-0.510	-0.210	0.090	0.147	0.259
PP5$3	-0.414	-0.302	-0.245	0.052	0.350	0.407	0.518
PP7$1	-3.096	-2.843	-2.713	-2.037	-1.360	-1.231	-0.977
PP7$2	-1.041	-0.923	-0.863	-0.549	-0.234	-0.174	-0.056

PP7$3	-0.572	-0.460	-0.403	-0.105	0.194	0.251	0.362
PP7$4	-0.414	-0.302	-0.245	0.052	0.350	0.407	0.518
PP8$1	-1.522	-1.389	-1.322	-0.967	-0.613	-0.545	-0.413
PP8$2	-1.426	-1.297	-1.231	-0.887	-0.543	-0.477	-0.348
CP2$1	-3.096	-2.843	-2.713	-2.037	-1.360	-1.231	-0.977
CP2$2	-1.257	-1.134	-1.071	-0.742	-0.412	-0.349	-0.226
CP3$1	-2.566	-2.366	-2.264	-1.732	-1.199	-1.097	-0.898
CP3$2	-1.041	-0.923	-0.863	-0.549	-0.234	-0.174	-0.056
CP4$1	-2.566	-2.366	-2.264	-1.732	-1.199	-1.097	-0.898
CP4$2	-2.053	-1.893	-1.811	-1.383	-0.955	-0.873	-0.713
CP4$3	-0.736	-0.623	-0.566	-0.264	0.037	0.095	0.208
TP1$1	-2.266	-2.091	-2.001	-1.534	-1.067	-0.977	-0.802
TP1$2	-1.257	-1.134	-1.071	-0.742	-0.412	-0.349	-0.226
TP1$3	0.056	0.174	0.234	0.549	0.863	0.923	1.041
TP2$1	-3.096	-2.843	-2.713	-2.037	-1.360	-1.231	-0.977
TP2$2	-2.266	-2.091	-2.001	-1.534	-1.067	-0.977	-0.802
TP2$3	-1.886	-1.736	-1.659	-1.258	-0.857	-0.780	-0.630
TP2$4	-0.466	-0.355	-0.298	0.000	0.298	0.355	0.466
TP3$1	-2.566	-2.366	-2.264	-1.732	-1.199	-1.097	-0.898
TP3$2	-1.748	-1.605	-1.532	-1.150	-0.769	-0.696	-0.553
TP3$3	-0.572	-0.460	-0.403	-0.105	0.194	0.251	0.362
TP4$1	-3.096	-2.843	-2.713	-2.037	-1.360	-1.231	-0.977
TP4$2	-2.053	-1.893	-1.811	-1.383	-0.955	-0.873	-0.713
TP4$3	-0.736	-0.623	-0.566	-0.264	0.037	0.095	0.208
TP5$1	-2.566	-2.366	-2.264	-1.732	-1.199	-1.097	-0.898
TP5$2	-1.748	-1.605	-1.532	-1.150	-0.769	-0.696	-0.553
TP5$3	-0.625	-0.513	-0.456	-0.157	0.142	0.199	0.311

TP6$1	-1.426	-1.297	-1.231	-0.887	-0.543	-0.477	-0.348
TP6$2	-0.362	-0.251	-0.194	0.105	0.403	0.460	0.572

Variances

F4	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Residual Variances

F1	-0.029	0.025	0.053	0.200	0.346	0.374	0.429
F2	0.000	0.090	0.135	0.375	0.615	0.660	0.750
F3	-0.224	-0.153	-0.117	0.072	0.260	0.297	0.367

New/Additional Parameters

COMP_REL	0.721	0.749	0.763	0.838	0.912	0.927	0.954

APPENDIX F: Full SAS Code and Results for Nonlinearity SEM Reliability of Latent Variables

SAS Input Code for Nonlinearity SEM Reliability of Study Latent Variable Goal Alignment

```
proc iml;
RESET fuzz;
THRESH={-2.037 -.610,-1.732 -.674,-.674 0,-2.307 -.610,-2.037 -.431};
LOAD={.837,.975,.798,.895,.698};
FACCOR={1};
POLY={1 .812 .442 .601 .669,.812 1 .773 .821 .754, .442 .773 1 .812 .451,
.601 .821 .812 1 .780, .669 .754 .451 .780 1};
NTHRESH=Ncol(thresh);
NCAT=NTHRESH+1;
NITEM=Nrow(LOAD);
NFACT=Ncol(LOAD);
POLYR=LOAD*FACCOR*T(LOAD);
do j=1 to NITEM;
POLYR[j,j]=1;
end;
DIFFPOLY=POLY-POLYR;
Print NTHRESH[label="Number of Thresholds"], NITEM[label="Number of
items"],
NCAT[label="Number of response categories"], NFACT[label="Number of
factors"],
THRESH[label="Response Thresholds"],LOAD[label="Factor Loadings"],
FACCOR[label="Factor Correlation Matrix"],
POLY[label="Polychoric Correlation Matrix among Continuous Items"] ;
print "The matrix below is the difference between polychoric
```

```
correlation matrix generated by factors and inputted polychoric
correlation matrix. Nonzero values should represent the estimated
correlated errors, as specified by the user, or an error in inputted
data.";
print DIFFPOLY[label=" "];
sumnum=0;
addden=0;
do j=1 to NITEM;
do jp=1 to NITEM;
sumprobn2=0;
addprobn2=0;
do c=1 to NTHRESH;
do cp=1 to NTHRESH;
sumrvstar=0;
do k=1 to NFACT;
do kp=1 to NFACT;
sumrvstar=sumrvstar+LOAD[j,k]*LOAD[jp,kp]*FACCOR[k,kp];
end;
end;
sumprobn2=sumprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],sumrvstar);
addprobn2=addprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],POLY[j,jp]);
end;
end;
sumprobn1=0;
sumprobn1p=0;
do cc=1 to NTHRESH;
sumprobn1=sumprobn1+CDF('NORMAL',THRESH[j,cc]);
```

```
sumprobn1p=sumprobn1p+CDF('NORMAL',THRESH[jp,cc]);
end;
sumnum=sumnum+(sumprobn2-sumprobn1*sumprobn1p);
addden=addden+(addprobn2-sumprobn1*sumprobn1p);
end;
end;
reliab=sumnum/addden;
print sumnum[label="Numerator of Eq. (21)"],
addden[label="Denominator of Eq. (21)"],
reliab[label="Nonlinear SEM Reliability Coefficient"];
quit;
```

SAS Nonlinear SEM Reliability Results for Study Latent Variable Goal Alignment

Number of Thresholds
2

Number ofitems
5

Number of response categories
3

Number offactors
1

Response Thresholds	
-2.037	-0.61
-1.732	-0.674
-0.674	0
-2.307	-0.61
-2.037	-0.431

Factor Loadings
0.837
0.975
0.798
0.895
0.698

Factor Correlation Matrix
1

Polychoric Correlation Matrix among Continuous Items				
1	0.812	0.442	0.601	0.669
0.812	1	0.773	0.821	0.754
0.442	0.773	1	0.812	0.451
0.601	0.821	0.812	1	0.78
0.669	0.754	0.451	0.78	1

The matrix below is the difference between polychoriccorrelation matrix generated by factors and inputted polychoriccorrelation matrix. Nonzero values should represent the estimatedcorrelated errors, as specified by the user, or an error in inputteddata.

0	-0.004075	-0.225926	-0.148115	0.084774
-0.004075	0	-0.00505	-0.051625	0.07345
-0.225926	-0.00505	0	0.09779	-0.106004
-0.148115	-0.051625	0.09779	0	0.15529
0.084774	0.07345	-0.106004	0.15529	0

SAS Nonlinear SEM Reliability Results for Study Latent Variable Goal Alignment (Cont'd)

Numerator of Eq. (21)
4.2714835

Denominator of Eq. (21)
4.9416058

Nonlinear SEM Reliability Coefficient
0.8643918

SAS Input Code for Nonlinearity SEM Reliability of Study Sub-factor Coordination

```
proc iml;
RESET fuzz;
THRESH={-2.037 -.610,-1.732 -.674,-.674 0,-2.307 -.610,-2.037 -.431};
LOAD={.837,.975,.798,.895,.698};
FACCOR={1};
POLY={1 .812 .442 .601 .669,.812 1 .773 .821 .754, .442 .773 1 .812 .451,
.601 .821 .812 1 .780, .669 .754 .451 .780 1};
NTHRESH=Ncol(thresh);
NCAT=NTHRESH+1;
NITEM=Nrow(LOAD);
NFACT=Ncol(LOAD);
POLYR=LOAD*FACCOR*T(LOAD);
do j=1 to NITEM;
POLYR[j,j]=1;
end;
DIFFPOLY=POLY-POLYR;
Print NTHRESH[label="Number of Thresholds"], NITEM[label="Number of
items"],
NCAT[label="Number of response categories"], NFACT[label="Number of
factors"],
THRESH[label="Response Thresholds"],LOAD[label="Factor Loadings"],
FACCOR[label="Factor Correlation Matrix"],
POLY[label="Polychoric Correlation Matrix among Continuous Items"] ;
print "The matrix below is the difference between polychoric
correlation matrix generated by factors and inputted polychoric
correlation matrix. Nonzero values should represent the estimated
```

```
correlated errors, as specified by the user, or an error in inputted
data.";
print DIFFPOLY[label=" "];
sumnum=0;
addden=0;
do j=1 to NITEM;
do jp=1 to NITEM;
sumprobn2=0;
addprobn2=0;
do c=1 to NTHRESH;
do cp=1 to NTHRESH;
sumrvstar=0;
do k=1 to NFACT;
do kp=1 to NFACT;
sumrvstar=sumrvstar+LOAD[j,k]*LOAD[jp,kp]*FACCOR[k,kp];
end;
end;
sumprobn2=sumprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],sumrvstar);
addprobn2=addprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],POLY[j,jp]);
end;
end;
sumprobn1=0;
sumprobn1p=0;
do cc=1 to NTHRESH;
sumprobn1=sumprobn1+CDF('NORMAL',THRESH[j,cc]);
sumprobn1p=sumprobn1p+CDF('NORMAL',THRESH[jp,cc]);
end;
```

```
sumnum=sumnum+(sumprobn2-sumprobn1*sumprobn1p);
addden=addden+(addprobn2-sumprobn1*sumprobn1p);
end;
end;
reliab=sumnum/addden;
print sumnum[label="Numerator of Eq. (21)"],
addden[label="Denominator of Eq. (21)"],
reliab[label="Nonlinear SEM Reliability Coefficient"];
quit;
```

SAS Nonlinear SEM Reliability Results for Study Sub-factor Coordination

Number of Thresholds
3

Number ofItems
2

Number of response categories
4

Number offactors
1

Response Thresholds		
-1.15	-0.967	0.21
-1.054	0.157	0

Factor Loadings
0.869
0.869

Factor Correlation Matrix
1

Polychoric Correlation Matrix among Continuous Items	
1	0.755
0.755	1

The matrix below is the difference between polychoriccorrelation matrix generated by factors and inputted polychoriccorrelation matrix. Nonzero values should represent the estimatedcorrelated errors, as specified by the user, or an error in inputteddata.

0	-0.000161
-0.000161	0

Numerator of Eq. (21)
2.8347264

Denominator of Eq. (21)
3.6602234

Nonlinear SEM Reliability Coefficient
0.7744681

SAS Input Code for Nonlinearity SEM Reliability of Study Latent Variable Credibility

```
proc iml;
RESET fuzz;
THRESH={-2.037 -1.534 -.431,-1.732 -1.383 -.105,-2.037 -1.383 0};
LOAD={.550,.985,.936};
FACCOR={1};
POLY={1 .542 .515,.542 1 .923,.515 .923 1};
NTHRESH=Ncol(thresh);
NCAT=NTHRESH+1;
NITEM=Nrow(LOAD);
NFACT=Ncol(LOAD);
POLYR=LOAD*FACCOR*T(LOAD);
do j=1 to NITEM;
POLYR[j,j]=1;
end;
DIFFPOLY=POLY-POLYR;
Print NTHRESH[label="Number of Thresholds"], NITEM[label="Number of
items"],
NCAT[label="Number of response categories"], NFACT[label="Number of
factors"],
THRESH[label="Response Thresholds"],LOAD[label="Factor Loadings"],
FACCOR[label="Factor Correlation Matrix"],
POLY[label="Polychoric Correlation Matrix among Continuous Items"] ;
print "The matrix below is the difference between polychoric
correlation matrix generated by factors and inputted polychoric
correlation matrix. Nonzero values should represent the estimated
correlated errors, as specified by the user, or an error in inputted
```

```
data.";
print DIFFPOLY[label=" "];
sumnum=0;
addden=0;
do j=1 to NITEM;
do jp=1 to NITEM;
sumprobn2=0;
addprobn2=0;
do c=1 to NTHRESH;
do cp=1 to NTHRESH;
sumrvstar=0;
do k=1 to NFACT;
do kp=1 to NFACT;
sumrvstar=sumrvstar+LOAD[j,k]*LOAD[jp,kp]*FACCOR[k,kp];
end;
end;
sumprobn2=sumprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],sumrvstar);
addprobn2=addprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],POLY[j,jp]);
end;
end;
sumprobn1=0;
sumprobn1p=0;
do cc=1 to NTHRESH;
sumprobn1=sumprobn1+CDF('NORMAL',THRESH[j,cc]);
sumprobn1p=sumprobn1p+CDF('NORMAL',THRESH[jp,cc]);
end;
sumnum=sumnum+(sumprobn2-sumprobn1*sumprobn1p);
```

```
addden=addden+(addprobn2-sumprobn1*sumprobn1p);
end;
end;
reliab=sumnum/addden;
print sumnum[label="Numerator of Eq. (21)"],
addden[label="Denominator of Eq. (21)"],
reliab[label="Nonlinear SEM Reliability Coefficient"];
quit;
```

SAS Nonlinear SEM Reliability Results for Study Sub-factor Credibility

Number of Thresholds
3

Number ofItems
3

Number of response categories
4

Number offactors
1

Response Thresholds		
-2.037	-1.534	-0.431
-1.732	-1.383	-0.105
-2.037	-1.383	0

Factor Loadings
0.55
0.985
0.936

Factor Correlation Matrix
1

Polychoric Correlation Matrix among Continuous Items		
1	0.542	0.515
0.542	1	0.923
0.515	0.923	1

The matrix below is the difference between polychoriccorrelation matrix generated by factors and inputted polychoriccorrelation matrix. Nonzero values should represent the estimatedcorrelated errors, as specified by the user, or an error in inputteddata.

0	0.00025	0.0002
0.00025	0	0.00104
0.0002	0.00104	0

Numerator of Eq. (21)
2.6187043

Denominator of Eq. (21)
3.1637553

Nonlinear SEM Reliability Coefficient
0.8277203

SAS Input Code for Nonlinearity SEM Reliability of Study Latent Variable Specialization

```
proc iml;
RESET fuzz;
THRESH={-1.732 -.210, -2.037 -.742,-1.383 -.210};
LOAD={.427,.512,.779};
FACCOR={1};
POLY={1 .219 .333,.219 1 .399,.333 .399 1};
NTHRESH=Ncol(thresh);
NCAT=NTHRESH+1;
NITEM=Nrow(LOAD);
NFACT=Ncol(LOAD);
POLYR=LOAD*FACCOR*T(LOAD);
do j=1 to NITEM;
POLYR[j,j]=1;
end;
DIFFPOLY=POLY-POLYR;
Print NTHRESH[label="Number of Thresholds"], NITEM[label="Number of
items"],
NCAT[label="Number of response categories"], NFACT[label="Number of
factors"],
THRESH[label="Response Thresholds"],LOAD[label="Factor Loadings"],
FACCOR[label="Factor Correlation Matrix"],
POLY[label="Polychoric Correlation Matrix among Continuous Items"] ;
print "The matrix below is the difference between polychoric
correlation matrix generated by factors and inputted polychoric
correlation matrix. Nonzero values should represent the estimated
correlated errors, as specified by the user, or an error in inputted
```

```
data.";
print DIFFPOLY[label=" "];
sumnum=0;
addden=0;
do j=1 to NITEM;
do jp=1 to NITEM;
sumprobn2=0;
addprobn2=0;
do c=1 to NTHRESH;
do cp=1 to NTHRESH;
sumrvstar=0;
do k=1 to NFACT;
do kp=1 to NFACT;
sumrvstar=sumrvstar+LOAD[j,k]*LOAD[jp,kp]*FACCOR[k,kp];
end;
end;
sumprobn2=sumprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],sumrvstar);
addprobn2=addprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],POLY[j,jp]);
end;
end;
sumprobn1=0;
sumprobn1p=0;
do cc=1 to NTHRESH;
sumprobn1=sumprobn1+CDF('NORMAL',THRESH[j,cc]);
sumprobn1p=sumprobn1p+CDF('NORMAL',THRESH[jp,cc]);
end;
sumnum=sumnum+(sumprobn2-sumprobn1*sumprobn1p);
```

```
addden=addden+(addprobn2-sumprobn1*sumprobn1p);
end;
end;
reliab=sumnum/addden;
print sumnum[label="Numerator of Eq. (21)"],
addden[label="Denominator of Eq. (21)"],
reliab[label="Nonlinear SEM Reliability Coefficient"];
quit;
```

SAS Nonlinear SEM Reliability Results for Study Sub-factor Specialization

Number of Thresholds
2

Number ofitems
3

Number of response categories
3

Number offactors
1

Response Thresholds	
-1.732	-0.21
-2.037	-0.742
-1.383	-0.21

Factor Loadings
0.427
0.512
0.779

Factor Correlation Matrix
1

Polychoric Correlation Matrix among Continuous Items		
1	0.219	0.333
0.219	1	0.399
0.333	0.399	1

The matrix below is the difference between polychoriccorrelation matrix generated by factors and inputted polychoriccorrelation matrix. Nonzero values should represent the estimatedcorrelated errors, as specified by the user, or an error in inputteddata.

0	0.000376	0.000367
0.000376	0	0.000152
0.000367	0.000152	0

Numerator of Eq. (21)
0.705961

Denominator of Eq. (21)
1.405762

Nonlinear SEM Reliability Coefficient
0.502191

SAS Input Code for Nonlinearity SEM Reliability of Study Latent Variable Project Performance

```
proc iml;

RESET fuzz;

THRESH={-1.732 -.674 -.264 -.157,-.887 -.742 0 0,-.264 0 .052 0,-2.037 -.210 .052 0,-2.037 -.549 -
.105 .052,

-.967 -.887 0 0};

LOAD={.663,.718,.845,.858,.597,.610};

FACCOR={1};

POLY={1 .406 .310 .704 .230 .338,.406 1 .681 .565 .514 .416,.310 .681 1 .648 .575 .663,.704 .565
.648 1

.369 .393,.230 .514 .575 .369 1 .440,.338 .416 .663 .393 .440 1};

NTHRESH=Ncol(thresh);

NCAT=NTHRESH+1;

NITEM=Nrow(LOAD);

NFACT=Ncol(LOAD);

POLYR=LOAD*FACCOR*T(LOAD);

do j=1 to NITEM;

POLYR[j,j]=1;

end;

DIFFPOLY=POLY-POLYR;

Print NTHRESH[label="Number of Thresholds"], NITEM[label="Number of

items"],

NCAT[label="Number of response categories"], NFACT[label="Number of

factors"],

THRESH[label="Response Thresholds"],LOAD[label="Factor Loadings"],

FACCOR[label="Factor Correlation Matrix"],

POLY[label="Polychoric Correlation Matrix among Continuous Items"] ;

print "The matrix below is the difference between polychoric
```

```
correlation matrix generated by factors and inputted polychoric
correlation matrix. Nonzero values should represent the estimated
correlated errors, as specified by the user, or an error in inputted
data.";
print DIFFPOLY[label=" "];
sumnum=0;
addden=0;
do j=1 to NITEM;
do jp=1 to NITEM;
sumprobn2=0;
addprobn2=0;
do c=1 to NTHRESH;
do cp=1 to NTHRESH;
sumrvstar=0;
do k=1 to NFACT;
do kp=1 to NFACT;
sumrvstar=sumrvstar+LOAD[j,k]*LOAD[jp,kp]*FACCOR[k,kp];
end;
end;
sumprobn2=sumprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],sumrvstar);
addprobn2=addprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],POLY[j,jp]);
end;
end;
sumprobn1=0;
sumprobn1p=0;
do cc=1 to NTHRESH;
sumprobn1=sumprobn1+CDF('NORMAL',THRESH[j,cc]);
```

```
sumprobn1p=sumprobn1p+CDF('NORMAL',THRESH[jp,cc]);
end;
sumnum=sumnum+(sumprobn2-sumprobn1*sumprobn1p);
addden=addden+(addprobn2-sumprobn1*sumprobn1p);
end;
end;
reliab=sumnum/addden;
print sumnum[label="Numerator of Eq. (21)"],
addden[label="Denominator of Eq. (21)"],
reliab[label="Nonlinear SEM Reliability Coefficient"];
quit;
```

SAS Nonlinear SEM Reliability Results for Study Sub-factor Project Performance

Number of Thresholds
4

Number ofItems
6

Number of response categories
5

Number offactors
1

Response Thresholds			
-1.732	-0.674	-0.264	-0.157
-0.887	-0.742	0	0
-0.264	0	0.052	0
-2.037	-0.21	0.052	0
-2.037	-0.549	-0.105	0.052
-0.967	-0.887	0	0

Factor Loadings
0.663
0.718
0.845
0.858
0.597
0.61

Factor Correlation Matrix
1

Polychoric Correlation Matrix among Continuous Items					
1	0.406	0.31	0.704	0.23	0.338
0.406	1	0.681	0.565	0.514	0.416
0.31	0.681	1	0.648	0.575	0.663
0.704	0.565	0.648	1	0.369	0.393
0.23	0.514	0.575	0.369	1	0.44
0.338	0.416	0.663	0.393	0.44	1

The matrix below is the difference between polychoriccorrelation matrix generated by factors and inputted polychoriccorrelation matrix. Nonzero values should represent the estimatedcorrelated errors, as specified by the user, or an error in inputteddata.

0	-0.070034	-0.250235	0.135146	-0.165811	-0.06643
-0.070034	0	0.07429	-0.051044	0.085354	-0.02198
-0.250235	0.07429	0	-0.07701	0.070535	0.14755

SAS Nonlinear SEM Reliability Results for Study Sub-factor Project Performance (Cont'd)

0.135146	-0.051044	-0.07701	0	-0.143226	-0.13038
-0.165811	0.085354	0.070535	-0.143226	0	0.07583
-0.06643	-0.02198	0.14755	-0.13038	0.07583	0

Numerator of Eq. (21)
34.059081

Denominator of Eq. (21)
41.01389

Nonlinear SEM Reliability Coefficient
0.830428

SAS Input Code for Nonlinearity SEM Reliability of Study Latent Variable Communication Performance

```
proc iml;

RESET fuzz;

THRESH={-2.037 -.742 0,-1.732 -.549 0,-1.732 -1.383 -.264};

LOAD={.852,.940,.698};

FACCOR={1};

POLY={1 .801 .595,.801 1 .656,.595 .656 1};

NTHRESH=Ncol(thresh);

NCAT=NTHRESH+1;

NITEM=Nrow(LOAD);

NFACT=Ncol(LOAD);

POLYR=LOAD*FACCOR*T(LOAD);

do j=1 to NITEM;

POLYR[j,j]=1;

end;

DIFFPOLY=POLY-POLYR;

Print NTHRESH[label="Number of Thresholds"], NITEM[label="Number of

items"],

NCAT[label="Number of response categories"], NFACT[label="Number of

factors"],

THRESH[label="Response Thresholds"],LOAD[label="Factor Loadings"],

FACCOR[label="Factor Correlation Matrix"],

POLY[label="Polychoric Correlation Matrix among Continuous Items"] ;

print "The matrix below is the difference between polychoric

correlation matrix generated by factors and inputted polychoric

correlation matrix. Nonzero values should represent the estimated

correlated errors, as specified by the user, or an error in inputted
```

```
data.";
print DIFFPOLY[label=" "];
sumnum=0;
addden=0;
do j=1 to NITEM;
do jp=1 to NITEM;
sumprobn2=0;
addprobn2=0;
do c=1 to NTHRESH;
do cp=1 to NTHRESH;
sumrvstar=0;
do k=1 to NFACT;
do kp=1 to NFACT;
sumrvstar=sumrvstar+LOAD[j,k]*LOAD[jp,kp]*FACCOR[k,kp];
end;
end;
sumprobn2=sumprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],sumrvstar);
addprobn2=addprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],POLY[j,jp]);
end;
end;
sumprobn1=0;
sumprobn1p=0;
do cc=1 to NTHRESH;
sumprobn1=sumprobn1+CDF('NORMAL',THRESH[j,cc]);
sumprobn1p=sumprobn1p+CDF('NORMAL',THRESH[jp,cc]);
end;
sumnum=sumnum+(sumprobn2-sumprobn1*sumprobn1p);
```

```
addden=addden+(addprobn2-sumprobn1*sumprobn1p);
end;
end;
reliab=sumnum/addden;
print sumnum[label="Numerator of Eq. (21)"],
addden[label="Denominator of Eq. (21)"],
reliab[label="Nonlinear SEM Reliability Coefficient"];
quit;
```

SAS Nonlinear SEM Reliability Results for Study Sub-factor Communication Performance

Number of Thresholds
3

Number ofItems
3

Number of response categories
4

Number offactors
1

Response Thresholds		
-2.037	-0.742	0
-1.732	-0.549	0
-1.732	-1.383	-0.264

Factor Loadings
0.852
0.94
0.698

Factor Correlation Matrix
1

Polychoric Correlation Matrix among Continuous Items		
1	0.801	0.595
0.801	1	0.656
0.595	0.656	1

The matrix below is the difference between polychoriccorrelation matrix generated by factors and inputted polychoriccorrelation matrix. Nonzero values should represent the estimatedcorrelated errors, as specified by the user, or an error in inputteddata.

0	0.00012	0.000304
0.00012	0	-0.00012
0.000304	-0.00012	0

Numerator of Eq. (21)
3.8751793

Denominator of Eq. (21)
4.7012568

Nonlinear SEM Reliability Coefficient
0.8242858

SAS Input Code for Nonlinearity SEM Reliability of Study Latent Variable Team Performance

```
proc iml;

RESET fuzz;

THRESH={-1.534 -.742 .549 0,-2.037 -1.534 -1.258 0,-1.732 -1.150 -.105 0,-2.037 -1.383 -.264 0,-
1.732 -1.150 -.157 0,-.887 .105 0 0};

LOAD={.750,.812,.741,.869,.744,.634};

FACCOR={1};

POLY={1 .582 .533 .695 .411 .577,.582 1 .704 .659 .597 .460,.533 .704 1 .582 .549 .460,.695 .659
.582 1 .705 .589,.411 .597 .549 .705 1 .422,.577 .460 .460 .589 .422 1};

NTHRESH=Ncol(thresh);

NCAT=NTHRESH+1;

NITEM=Nrow(LOAD);

NFACT=Ncol(LOAD);

POLYR=LOAD*FACCOR*T(LOAD);

do j=1 to NITEM;

POLYR[j,j]=1;

end;

DIFFPOLY=POLY-POLYR;

Print NTHRESH[label="Number of Thresholds"], NITEM[label="Number of

items"],

NCAT[label="Number of response categories"], NFACT[label="Number of

factors"],

THRESH[label="Response Thresholds"],LOAD[label="Factor Loadings"],

FACCOR[label="Factor Correlation Matrix"],

POLY[label="Polychoric Correlation Matrix among Continuous Items"] ;

print "The matrix below is the difference between polychoric

correlation matrix generated by factors and inputted polychoric

correlation matrix. Nonzero values should represent the estimated
```

```
correlated errors, as specified by the user, or an error in inputted
data.";
print DIFFPOLY[label=" "];
sumnum=0;
addden=0;
do j=1 to NITEM;
do jp=1 to NITEM;
sumprobn2=0;
addprobn2=0;
do c=1 to NTHRESH;
do cp=1 to NTHRESH;
sumrvstar=0;
do k=1 to NFACT;
do kp=1 to NFACT;
sumrvstar=sumrvstar+LOAD[j,k]*LOAD[jp,kp]*FACCOR[k,kp];
end;
end;
sumprobn2=sumprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],sumrvstar);
addprobn2=addprobn2+probbnrm(THRESH[j,c],THRESH[jp,cp],POLY[j,jp]);
end;
end;
sumprobn1=0;
sumprobn1p=0;
do cc=1 to NTHRESH;
sumprobn1=sumprobn1+CDF('NORMAL',THRESH[j,cc]);
sumprobn1p=sumprobn1p+CDF('NORMAL',THRESH[jp,cc]);
end;
```

```
sumnum=sumnum+(sumprobn2-sumprobn1*sumprobn1p);
addden=addden+(addprobn2-sumprobn1*sumprobn1p);
end;
end;
reliab=sumnum/addden;
print sumnum[label="Numerator of Eq. (21)"],
addden[label="Denominator of Eq. (21)"],
reliab[label="Nonlinear SEM Reliability Coefficient"];
quit;
```

SAS Nonlinear SEM Reliability Results for Study Sub-factor Team Performance

Number of Thresholds
4

Number ofItems
6

Number of response categories
5

Number offactors
1

Response Thresholds			
-1.534	-0.742	0.549	0
-2.037	-1.534	-1.258	0
-1.732	-1.15	-0.105	0
-2.037	-1.383	-0.264	0
-1.732	-1.15	-0.157	0
-0.887	0.105	0	0

Factor Loadings
0.75
0.812
0.741
0.869
0.744
0.634

Factor Correlation Matrix
1

Polychoric Correlation Matrix among Continuous Items					
1	0.582	0.533	0.695	0.411	0.577
0.582	1	0.704	0.659	0.597	0.46
0.533	0.704	1	0.582	0.549	0.46
0.695	0.659	0.582	1	0.705	0.589
0.411	0.597	0.549	0.705	1	0.422
0.577	0.46	0.46	0.589	0.422	1

The matrix below is the difference between polychoriccorrelation matrix generated by factors and inputted polychoriccorrelation matrix. Nonzero values should represent the estimatedcorrelated errors, as specified by the user, or an error in inputteddata.

0	-0.027	-0.02275	0.04325	-0.147	0.1015
-0.027	0	0.102308	-0.046628	-0.007128	-0.054808
-0.02275	0.102308	0	-0.061929	-0.002304	-0.009794

SAS Nonlinear SEM Reliability Results for Study Sub-factor Team Performance (Cont'd)

0.04325	-0.046628	-0.061929	0	0.058464	0.038054
-0.147	-0.007128	-0.002304	0.058464	0	-0.049696
0.1015	-0.054808	-0.009794	0.038054	-0.049696	0

Numerator of Eq. (21)
25.179458

Denominator of Eq. (21)
30.225111

Nonlinear SEM Reliability Coefficient
0.8330642

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