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THE IMPACT OF THE BUSINESS-PROJECT INTERFACE ON CAPITAL PROJECT PERFORMANCE

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THE IMPACT OF THE BUSINESS-PROJECT INTERFACE ON CAPITAL PROJECT PERFORMANCE

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Dedication

To my beloved family:

Who always give me unconditional support and love

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A capital project represents a significant investment by a firm to create future economic benefits. Since the global economic recession begun in 2008, corporate owners have paid increased attention to business-project interfaces with the aim of improving alignment between business strategy and capital project development. Despite its importance, the business-project interface has not been quantitatively measured and no empirical evidence exists about its effects on performance outcomes. This dissertation intends to identify and quantify the business-project interfaces in the development of a capital project in terms of personnel involvement and task interaction, and to investigate its effects on performance outcomes and the value of best practices. To achieve these objectives, a conceptual framework for assessing the involvement and interaction on business-project interfaces was developed. Based on the conceptual framework, a

questionnaire including quantitative measures for the assessment of personnel involvement and task interaction was designed. Supplemental survey responses were received for several industrial capital projects that had initially provided capital project data to the CII Benchmarking & Metrics database. The effects of the business-project interface in terms of cost, schedule, change, and business performance were documented. Data analyses show that project groups with high involvement by business personnel and high interaction between business and project units tend to show remarkably improved project performance. Furthermore, this dissertation presents confirmation that projects with high involvement of business unit personnel and intensive implementation of best practices tend to show superior project performance. The primary contribution of this research is to provide a quantitative assessment tool to assess the business-project interface and to document the interface throughout project life cycle. Another contribution is empirical evidence of the benefits on project performance from implementing best practices that were supported by management.

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CHAPTER 1: INTRODUCTION

1.1 RESEARCH MOTIVATION

Since the economic recession that started in 2008, the U.S. has experienced a long and slow recovery. The impact of the U.S. economic downturn has begun to show in the construction spending of large corporate owners. Corporate owners have worried about their ability to find the resources to do all the work that needed to be done. They've been hesitant to invest their capital. Budget cuts have necessitated a thorough reevaluation of their capital projects plan (ENR 2009). Engineering New Record (ENR) reported that construction spending by the ENR Top 425 Owners dropped 5.4% in 2009 to $154.8 billion from $163.6 billion in 2008, according to their filings with the U.S. Securities and Exchange Commission (ENR 2010).

Under these uncertain economic circumstances, corporate owners need to flexibly cope with the rapidly changing business environment as well as effectively manage their capital projects. To accomplish this, corporate owners need to be able to adjust the scope of a project if the business environment has changed, and such a change achieves the business objectives of the project. Therefore, corporate business personnel from top or senior management should be more integrated in the development of a capital project, and spontaneous interaction with project personnel should be facilitated to more effectively manage the capital project. Although the involvement of business and project personnel and their task interactions in the development of a capital project is important, one of the critical things that are problematic in the capital project development process across the industry is a lack of cooperation and understanding across functions (NRC

2003). Corporate owners have struggled to align their business strategy with project management (Srivannaboon 2006). This is interface problem between business and project personnel might hinder the rapid and flexible adjustment of project scope, and could lead to a misalignment of goals and objectives among business and project personnel. These interface issues have not been paid adequate attention by project management research. In fact, interface problems often occur much earlier between business and project personnel within an owner's organization.

Despite the fact that interface problems between business and project personnel of a corporate owner can occur much earlier than the initiation phase of a given project, most studies have so far focused on technical and process interface problems and their management in the project execution phase. These studies focused on inter-organizational interface problems between a contractor and other project participants such as the owner, other contractors, subcontractors, suppliers. It is difficult to assess the subtle and non-technical interface, particularly organizational interface problems between business and project unit personnel in a corporate owner organization and their effects on project performance. There is a lack of quantitative assessment tools and appropriate metrics. A quantitative assessment tool needs to be developed to measure a corporate owner's organizational interfaces in the development of a capital project, and to investigate their impacts on project performance and outcomes.

1.2 RESEARCH OBJECTIVES

The primary objective of this research is to identify interfaces between business and project units and to quantify their involvement and interaction. The first problem is that information on the actual interface between the business and project unit has not been documented. Therefore, a thorough understanding of the business-project alignment and how business and project unit personnel are involved and how they interact with each other in the development of a capital project is missing. It is necessary to obtain quantitative information about the interface between the business and project unit. To address this need, this research will develop a questionnaire and will conduct a survey to collect quantitative data about the involvement of management personnel and to measure task interactions throughout capital project delivery. The quantified data can be used to evaluate the current status of business-project interface and will provide the fundamental basis for the development of effective interface management practices and future research strategies to improve the business-project alignment.

This research aims to examine quantitatively the effects of the extant business project interface on project performance outcomes. Project performance outcomes that will be considered include cost, schedule, change performance, and achievement of business objectives. Management practices such as front end planning, alignment during front end planning, partnering, team building, project delivery and contract strategy, will be examined as well.

1.3 RESEARCH SCOPE

This research is about the business-project interface that exists between the business and project unit of an owner organization, particularly a corporate owner who is funded to obtain or maintain fixed assets through capital project delivery. The term "interface" is different from "interface management." While interface management deals with management practices and processes used to manage interfaces effectively, the interface focuses on the current status of how the interface exists and how it works. This research focuses on investigating the current state of business-project interface the between business and project unit.

This research focuses on business-project interfaces throughout the overall project life cycle from project initiation to project termination. Operations and maintenance after project completion are excluded. The research brings into focus the work functions in which business and project personnel are involved and documents how they interact with each other. The research also investigated the level of involvement of management personnel who are involved in the development of a capital project. Involvement was investigated for senior management personnel, functional management personnel, and project management personnel. The project data utilized by this research were extracted from the Construction Industry Institute (CII) Benchmarking & Metrics database and the survey was distributed to CII owner member companies. Most owner companies which participate in the CII Benchmarking & Metrics program are large and leading companies in the market. Thus, the findings from the research represent the large company perspective rather than that of a small or medium-sized company.

1.4 ORGANIZATION OF DISSERTATION

The dissertation is organized of seven chapters. Chapter 1 presents the motivation, objectives, and scope of the research. Chapter 2 provides research background. In Chapter 2, research needs are assessed through a literature review of relevant interface studies. Building from the discussion of introduced by the literature review, the business-project interface is conceptually established. The conceptual framework provides a theoretical framework on how to investigate interfaces between the business and project unit. Based on the established conceptual framework, the model for this research is developed. The research model presents what associations need to be examined in this research. From the research model, three main research questions are addressed in accordance with research gaps and needs identified by the literature review. Chapter 3 explains the methodology for this research. The research methodology presents how the questionnaire is developed, what data are needed and how to collect them through survey. Descriptive statistics of project data are also summarized.

Chapter 4 describes the current state of the business-project interface as documented through analysis of the quantitative information collected by the questionnaire survey. The framework on the business-project interface is described in terms of personnel involvement and task interaction. The assessment of personnel involvement includes the total work-hours of management personnel who are involved in a project in terms of phase participation and time distribution. In other words, the survey captures who participated in each project phase and how they distributed their work-

hours in each project phase. Task interaction is measured by assessing the task level collaboration between the business and the project unit work for a specific work function.

Chapter 5 quantitatively investigates effects of the business-project interface on project performance outcomes. The effects of the business-project interface on project performance outcomes are provided in terms of the effects of personnel involvement and the effects of task interaction, respectively. In addition, the interaction effects of personnel involvement and task interaction on project performance outcomes are investigated. This chapter provides the synergy impacts of personnel involvement and task interaction as well as their direct impacts on performance outcomes. Project performance outcomes include project cost growth, project schedule growth, change cost factor, and achievement of business objectives which are extracted from the CII Benchmarking & Metrics (BM&M) database.

Chapter 6 examines effects of the business-project interface on value of best practices. The relationships between the involvements of business personnel and best practices are investigated and then the interaction effects of the involvement of business personnel and best practices implementation on performance outcomes are examined. The implementation level of CII best practices will be evaluated with the performance data from the CII BM&M database. The CII best practices are front end planning, alignment during front end planning, partnering, team building, project delivery and contract strategy, constructability, project risk assessment, change management, zero accident techniques, and planning for startup. This chapter provides the key business personnel who are significantly correlated with better implementation of best practices

and leverage effects of involvement of business unit personnel and best practices implementation on improved performance outcomes.

Finally, Chapter 7 summarizes the main findings based on the research questions and provides both academic and practical contributions of this research. The chapter also discusses limitations and suggests future research that can build on the findings of this dissertation.

CHAPTER 2: RESEARCH BACKGROUD

This chapter presents findings from previous studies related to interface management in the fields of business and project management. First, it reviews existing definitions and concepts for interface management and explains the relationship of interface management with organizational performance. Second, the conceptual framework for the business-project interface is developed based on the extensive literature review. Third, research questions and propositions are addressed based on issues derived from the extensive literature review and the conceptual framework.

2.1 INTERFACE MANAGEMENT: LITERATURE REVIEW

2.1.1 Interface Management in the Capital Project Industry

Capital projects have been getting larger recently, and more technically complex in the asset-intensive industries (Hundetmark et al, 2008). Asset-intensive industries usually create economic benefits from fixed assets such as facilities and plants. In such industries, the size and complexity of a capital project leads to various interface issues. Interface issues and their management have only just begun to be addressed by construction research, although experienced industrial practitioners have long emphasized the severity of effects from interface problems and the necessity for interface management in the construction industry (Noteboom 2004; Crumrine et al. 2005; Pavitt and Gibb, 2003; O'Connor et al. 1997; M.J. O'Brien et al. 2000; M.J. O'Brien and Willmott, 2001; Pavitt and Gibb, 2003; Sundgen 1999).

Several studies have attempted to identify interface issues during project execution and to suggest ways to manage them through various interface boundaries

between organizations, contracts, methods, processes, and systems (Al-Hammad 1990; Shrive 1992; Sozen 1996; O'Brien and Willmott 2001; Pavitt and Gibb 2003; Nooteboom 2004; Crumrine et al. 2005). Most studies have been structured to examine the interrelationships among different type of interface issues (Critisinelis 2001; Pavitt and Gibb 2003; Chen et al. 2008). Some studies focused on interface issues in one specific area such as physical interface (Pavitt et al. 2001; Pavitt and Gibb 2003), design-construction interface (Alarcon and Mardones 1998; Khanzode et al. 2000; Miles and Ballard 2002), intercompany interface (Al-Hammad and Assaf 1992; Hinze and Tracey 1994; Al-Hammad 2000), and process interface (Chen et al. 2005).

Proposed approaches for interface management have been developed for technical and process interface management between the design and construction phase, and also within construction phases, such as in a quality control system (Alarcon and Mardones 1998), or a matching system for materials and methods (Pavitt and Gibb 2003). Chua and Godinut focused on interface object modeling through information technology (IT) applications and a work breakdown structure (WBS) matrix-based interface management technique (Chua and Godinut 2006) and Lin developed a network-based interface management system for construction management (Lin 2009). In summary, technical interface issues have been relatively well-researched, planned, and considered during project execution. On the other hand, non-technical interface issues stemming from organizational issues are often the most challenging for a capital project (Nooteboom 2004). In spite of their importance, organizational interface issues have not received adequate recognition compared to other technical/process interface problems. In summary, interface studies to this point have mainly focused on technical interfaces and their management during project execution, to the detriment of non-technical interface issues.

2.1.2 Organizational Interface Management

Interfaces are defined as internal if the work concerned is done within one organization, or external, if different organizations collaborate (Healy 1997). Multiple organizational interfaces exist amongst project participants during the development and execution of a capital project. Stuckenbruck (1998) pointed out that organizational interfaces are the most problematic because they are associated not only with people but also various organizational goals, and management styles. Each organizational unit has its own goals and objectives, disciplines or specialties, and functions. These differences provoke misalignment and conflict between different organizational units. This kind of interface occurs day-to-day at the task level both within and between organizations. In contrast, pure management interfaces typically exist only whenever important decisions, approvals, or other actions that affect the project must be made (Stuckenbruck, 1998). Interface management in the field of project management includes managing human relationships in the project organization, maintaining a balance between technical and managerial project functions, coping with risk associated with the project, and handling organizational restraints which have a tendency to develop into organizational conflict (Kerzner 1992).

In the capital project industry, most studies have dealt with specific organizational interfaces in a particular construction area or project stage during a specific time frame. The specific type of organizational interfaces that have been examined include: owners vs. designers/engineers (Al-Hammad and Al-Hammad 1996), owners vs. contractors (Al-Hammad 1990; Al-Hammad 1995), designer/engineers vs. contractors (Al-Hammad and Assaf 1992), contractors vs. contractors (Al-Hammad 2000; Pavitt and Gibb 2003),

contractors vs. subcontractors (Al-Hammad 1993; Hinze and Andres 1994). These studies focused on inter-organizational interfaces during design and construction and were focused on project controls rather than planning. Interface problems often occur much earlier, however, between the business and project unit within the owner's organization. These interface issues, moreover, give rise to misalignment of business strategy with project management.

2.1.3 Business-Project Interface

The business-project interface and its management have not been fully recognized in the capital project industry. From the perspective of project integration, Stuckenbruck (1998) defined them as management interfaces which occur when combining personal and organizational interfaces. He determined that management interfaces occur between the project manager and functional manager, the project manager and top management, between different functional managers, and even sometimes between different project managers. Among these management interfaces, Kerzner (1992) and Stuckenbruck (1998) asserted that the most important interface is between the project manager and the various functional managers supporting the capital project because these relationships are almost inevitably adversary and involve a constantly shifting balance of power between two managers on essentially the same reporting level. In other words, since a project manager does not have enough authority to directly control all required resources such as money, manpower, equipment, facilities, materials, information, and technology, the project manager must negotiate and collaborate with various functional managers (Kerzner 1992). Consequently, a potential source of conflict is latent within the interface between the project manager and functional managers.

In addition, Kerzner (1992) addressed the importance of the project-sponsor interface. He pointed out that the reason why executives meddle during project execution is that they feel that they are not getting accurate information from the project manager in terms of project status. He predicted that if project managers provide executives with timely, accurate, and complete information for decision-making, then the meddling of executives would be reduced or even eliminated. Stuckenbruck (1998) also emphasized that the interface with top management is important because it represents the project manager's source of authority and responsibility. To manage a project successfully, he pointed out that project managers need not only strong support from top management but also a communication link which is used to contact top management whenever necessary.

Despite its importance, few studies have focused on management interfaces between the business and project unit in terms of organizational involvement and interaction. As pointed out by Chen et al. (2008), organizational involvement and interaction are unavoidable and need to be properly coordinated to prevent various negative impacts on project performance. One approach is organizational involvement which deals with the participation of management personnel in project management or other business functions. In particular, studies on personnel involvement and the interface between the business and project unit have focused on top management support and involvement (Fortune and White, 2006; Zwikael 2008), and on the project sponsor and sponsorship (Wright, 1997; Bryde 2008). Another approach to address management interface issues is organizational collaboration and interaction, such as cross-functional collaboration or project -functional manager collaboration (Pitagorsky, 1998).

Fortune and White (2006) and Zwikael (2008) asserted that top management support must be recognized as a critical success factor and that it has a positive influence on project performance. Wright (1997) and Bryde (2008) investigated the impact of the

project sponsor, who is responsible to the business for the success of the project, on project success and determined that the greater the project sponsorship effort the greater the perceived level of project success. Pitagorsky (1998) emphasized that the collaborative relationship between function managers and project managers is critical to effective project performance. All of these studies however, explained organizational interaction and involvement using qualitative approaches. To date, few attempts have been made to measure the level of involvement and interaction of owner's key personnel who participate in the development of a capital project in a quantitative manner.

2.1.4 Measurement of Interface Management

Most of the studies found by the literature review investigated organizational involvement and interaction through qualitative approaches such as case studies and focus group interviews. (Forture and White 2006; Zwikael 2008; Wright 1997; Bryde 2008; Pitagorsky 1998).

Table 2.1 Measurement of Organizational Interaction and Involvement

Previous Study	Measurement Metrics	Measurement Scale	Definition
Cohenza-Zall et al. (1994)	Degree of Involvement	Ordinal (Likert Scales)	6 level scale from "Not at all (0)" to "Very High (6)"
Chiocchio et al. (2010)	Project Involvement Index	Interval (Ratio)	The product of the number of projects and the proportion of time spent working on projects
Pocock et al. (1996)	Degree of Interaction	Interval (Ratio)	The ratio between the weighted total man-hours spent on interaction and the construction duration

As shown in Table 2.1, only a few attempts have been made to quantitatively measure involvement and interaction of project participants through the use of subjective assessment using Likert scale responses captured by on-site interviews (Cohenza-Zall et al. 1994), and by quantitative measures from project information (Chiocchio et al. 2010; Pocock et al. 1996). However, these existing approaches to measure organizational involvement and interaction among project participants were applied to examine inter-organizational relationships during project execution. Thus, it is necessary to develop quantitative measures to evaluate the level of involvement of owner's management personnel and the level of interaction between business and project unit.

2.1.5 Summary of Literature Review

In summary, four main research gaps were addressed by the literature review. Figure 2.1 summarized what has been studied in existing studies and what needs to be studied in this research. Each research need is related to each research gap.

First, existing studies focused on inter-organizational interfaces between project participants in project execution such as owner-designer interfaces, owner-contractor interfaces, owner-suppliers interfaces, owner-maintenance operator interfaces, designer-contractor interfaces, and contractor-contractor interfaces. Therefore, the intra-organizational interfaces within an owner organization throughout capital project delivery need to be examined particularly in terms of the interfaces between business and project unit that have existed but have not been properly recognized for a long time.

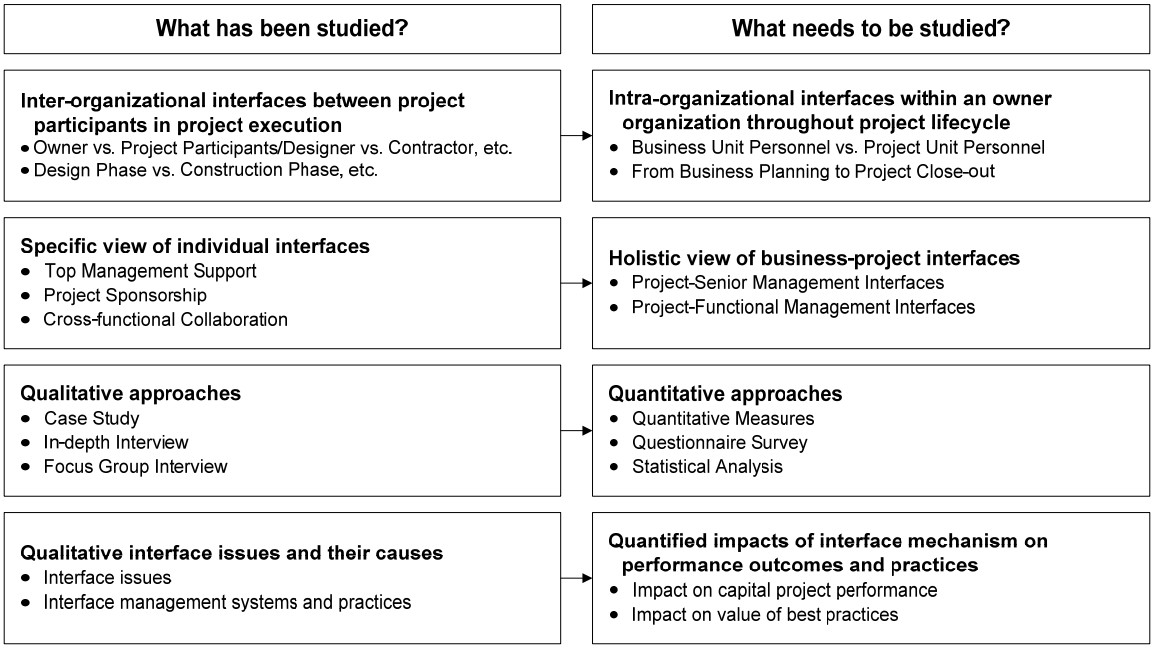


Figure 2.1 Summary of Literature Review

Second, most previous studies were conducted through qualitative approaches such as case study, in-depth interview, and focus group interview. Qualitative approaches have benefits to examine specific interface issues and their causes, and interface management cases. However, it is difficult to obtain quantitative information on management efforts on the interface between business and project unit. Therefore, quantitative approaches need to be used to quantify management efforts on business-project interfaces and to investigate their effects on performance outcomes.

Third, a few attempts existed to examine the business-project interfaces and their relationships with capital project performance but most existing studies dealt with specific business-project interface such as top management support, project sponsorship, and cross-functional collaboration. Therefore, the business-project interface need to be

examined based on holistic view of the business-project interface including project-senior management interfaces and project-functional management interfaces.

Forth, existing studies focused on identifying causes and effects of interface issues which exist between project participants or between phases, and then providing management efforts or management systems to alleviate the interface issues. However, the business-project interfaces needs to be quantitatively examined first, and then the quantified impacts of the business-project interface on performance outcomes need to be investigated in terms of capital project performance and value of best practices.

2.2. CONCEPTUAL FRAMEWORK FOR IDENTIFYING BUSINESS-PROJECT INTERFACE

Based on the issues identified by the literature review, a conceptual framework for capturing the business-project interface between the business and project unit was developed and is shown in Figure 2.2. The conceptual framework provides a holistic view in terms of the interface between project and top management and the interface of the project manager to functional management. This framework between business personnel and project personnel can be defined by the task-based involvement of management personnel and by the task-level interactions between the business and project units throughout the capital project development and execution process. This research establishes a business-project interface in order to describe how the business and project unit personnel are involved in the development of a capital project and to capture how they interact with each other in the course of conducting tasks or work functions for a project.

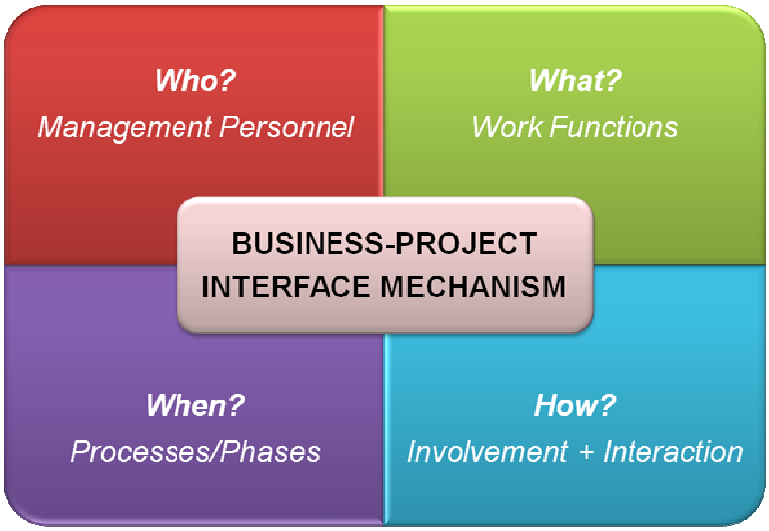


Figure 2.2 Conceptual Framework for Identifying Business-Project Interface

The conceptual framework consists of the following four major components: "who," "when," "what," and "how." The first component indicates the business and project personnel who are involved in the development of a capital project and interact with each other within an owner's organization. The second component, "when," is the processes and phases where the interfaces among the individuals and organizations exist during the development of a capital project. The third component, "what," includes the work functions and tasks that require personnel involvement and interaction between management personnel in the development of a capital project. The final component, "how," is the way business and project unit personnel are involved in the development of a capital project and how they interact with each other.

This component "how" is given the most focus in this research. Based on the conceptual framework for identifying business-project interface, personnel involvement

and task interaction are measured. The current states of business-project interfaces are described and validated in Chapter 4 and their effects are examined in Chapter 5.

2.2.1 Management Personnel

To build the conceptual framework, this research began by identifying the management personnel in an owner organization. They comprise the first component in the conceptual framework and are key players in the development of a capital project. As usual, the term "owner" is used to identify a group of business executives and managers as well as the project management team members who are part of the owner's organization. Many different entities such as business executives and functional personnel within an owner organization participate at various times over the life cycle of a capital project (CII 2006).

A number of previous studies have emphasized the importance of the owner's roles in project management of a capital project (CII 2003a; NRC 2005; CII 2006). The CII Research Team (RT) 190 (2003) examined the outcomes when an owner is proactively and directly involved in project safety practices during the construction phase and confirmed that it leads better safety performance. The committee for oversight and assessment of the U.S. in the National Research Council addressed the owner's role in project risk management for Department of Energy (DOE) projects in terms of the owner's representatives, including senior managers, program managers, project directors, and project managers (NRC 2005). The CII RT 204 (2006) established that the owner's

role in project success hinged on its ability to identify the correct management approach for different types of projects, delivery systems, and team structures.

The RT 204 defined the owner as "*the entity that holds the ultimate decision making authority and has responsibilities for establishing the basic objective of the project that will serve as the justification for securing funding for the project and will, upon completion of the project, own and operate the facility*" (2006). Management personnel have various levels of responsibility and authority when participating on a project and these can change over the course of the project life cycle (PMI 2008). The participation of management personnel and the level of their involvement in a capital project depend often on the nature of the project. The diversity of project unit personnel from an owner organization that may be involved has been relatively well-identified and researched by previous studies, however.

On the other hand, scant documentation of the participation of the owner's business unit personnel in development of a capital project was found in the existing literature on capital project research. Morrow (2011) mentioned that the role of the owner team is to create comparative advantage for the owner organization. This team is where all of the owner functions come together to take advantage of the business opportunity and generate a project that is fashioned to the particular strengths and talents of the organization. He listed thirty-seven positions of the core owner team members who may be involved in an industrial megaproject based on the functional basis including business, project management, professional services, engineering/process, project controls, construction, contracts, environment/health/safety, procurement, finance, local

government/authorities, and operations/maintenance. Considering that those positions are part of the core owner team, this research selected business and project unit personnel who could be involved in a capital project based on the conceptual framework as can be seen in Table 2.2.

Table 2.2 Management Personnel in Business and Project Unit

Unit	Category	Management Personnel
Business	**Senior Management Personnel (3)**	• Chief Executive Officer • Business Unit Manager • Project Sponsor/Executive Sponsor
	Functional Management Personnel (9)	• Accounting Manager • Finance Manager • Marketing Manager • Human Resource Manager • Information Technology Manager • Contract/Legal Manager • Facility/Plant Manager • Operations/Production Manager • Portfolio/Program Manager
Project	**Project Management Personnel (8)**	• Project Manager • Project Controls Manager/Engineer • Engineering Manager • Engineering Team Discipline Lead • Procurement Manager • Construction Manager • Quality Assurance/Quality Control (QA/QC) Manager • Health/Safety/Environment (HSE) Manager

An owner's business management personnel can be categorized into two groups according to their roles and responsibilities: senior management and functional management. The senior management personnel are senior/business executives at the highest level of an organization who are responsible for managing the day-to-day operations of a company or corporation. Senior management can be referred to variously as executive management, top management, upper management, or higher management.

Senior management personnel roles include chief executive officer, business unit manager, and project sponsor. Senior management personnel typically find business opportunities, develop strategic plans, analyze feasibility, support the project management team, and make important decisions whether to proceed or not.

Functional management personnel are key individuals who play a management role within an administrative or functional area of the business, such as accounting, finance, marketing, human resources, information technology, contract/legal, operations/ production, facility/plant, and portfolio/program. The functional managers are assigned their own permanent staff to carry out the ongoing work, and they have a clear directive to manage all tasks within their functional area of responsibility, and provide subject matter expertise or service to the project (PMI 2008).

The project management personnel are responsible for managing project functions to achieve project objectives. Project management personnel include the project manager, project control manager, engineering manager, engineering team leads, construction manager, procurement manager, quality assurance/quality control (QA/QC) manager, health/safety/environmental (H/S/E) manager, and other project team members.

2.2.2 Phases/Processes

The CII RT 204 emphasized that the owner must be involved with the project throughout the entire life cycle as shown in Figure 2.3 that was developed by the RT 155 (1999). The research team emphasized that the owner needs to determine the appropriate level of involvement during each phase, from project initiation to project close-out. The

RT 204 (2006) briefly addressed the owner's involvement in each phase during the project life cycle. The early planning phase involves the owner entities such as strategic business development and marketing, facilities operations and maintenance, and program and project management personnel for ensuring that the owner's goal and objectives of the project are accomplished.

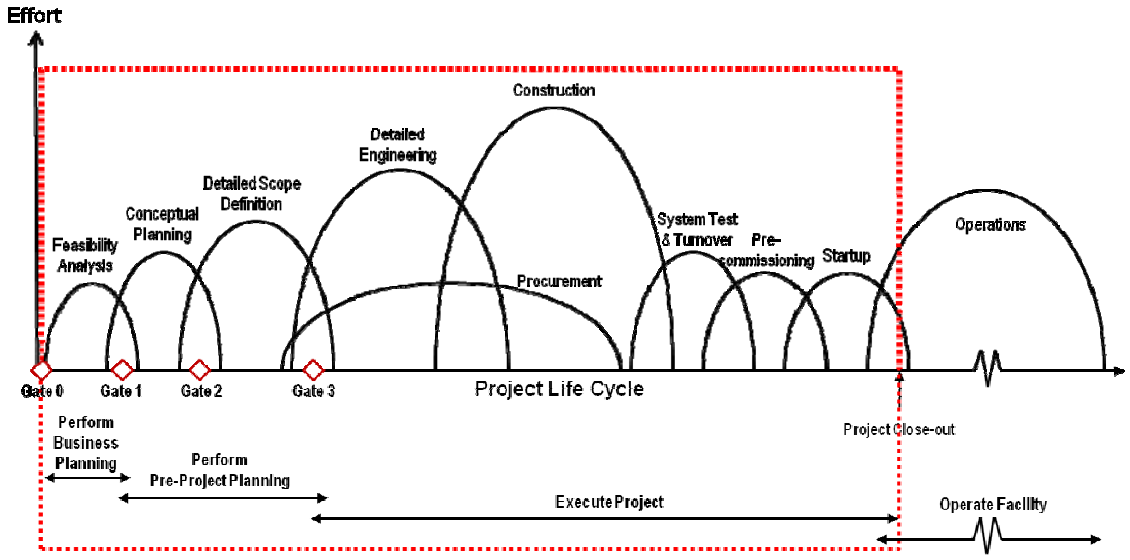


Figure 2.3 Project Life Cycle Overlap Diagram (CII, 1994)

In the project execution phase, the owner's engineering and construction functions should be involved. In addition, the owner's finance and legal functions may be involved in these phases providing budgeting oversight and dispute resolution assistance respectively. In the detailed engineering phase, the facilities, program and project management, construction management functions, and representatives of the end user

should be adequately involved. In the construction phase, the involvement of the owner's project management and construction management functions varies from limited to heavy. Finally, the owner's operations and maintenance functions are involved in the startup and commissioning phase.

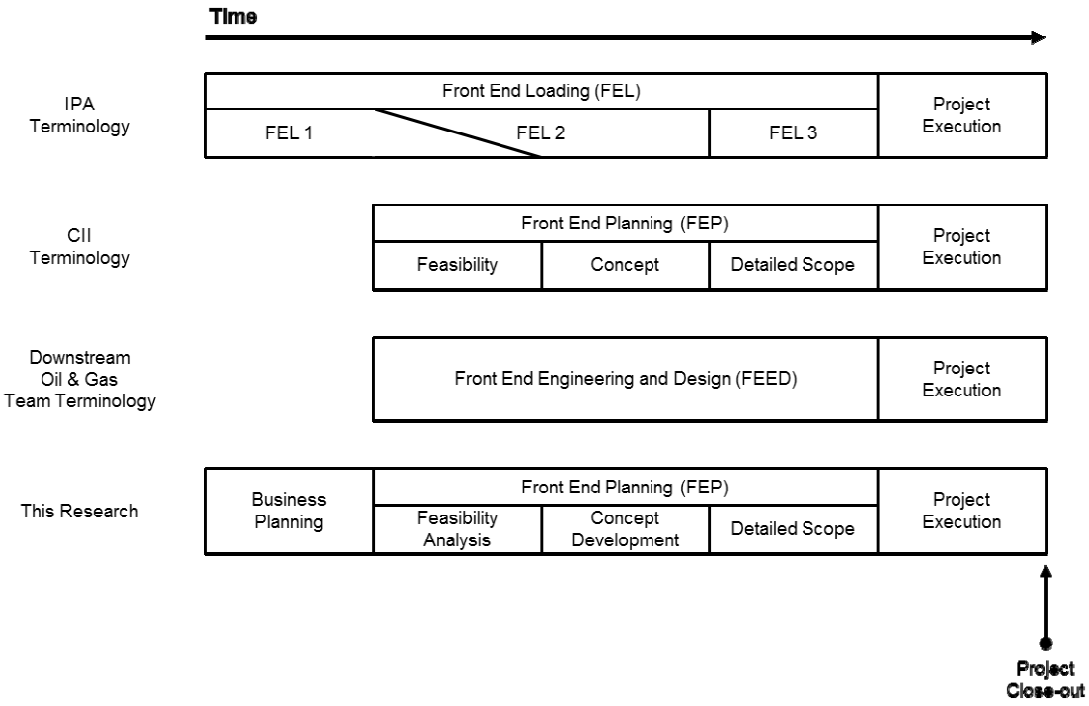


Figure 2.4 Alignment of Different Phase Definitions

As can be seen in Figure 2.4, there are several common terms used by the industry to refer to activities within the phase that is focused on the development of a capital project. Among these phase definitions, differences exist on whether the business cases/planning is included in one of these phases. For example, the FEL 1 phase used by Independent Project Analysis (IPA) includes business cases as part of the development of

a capital project (Morrow 2011), but CII's front end planning (FEP) does not. It can be reasonably presumed that management personnel in an owner organization may be involved earlier than feasibility analysis. This research does include business planning prior to feasibility analysis. In addition, this research includes project close-out as the last phase in the project life cycle because this phase is performed once all defined project objectives have been met.

2.2.3 Work Functions

This research is focused on understanding and quantifying the interface that exists between business and project unit personnel. Forty work functions were identified in which business and project representatives might collaborate, as shown in Table 2.3. Not surprisingly, the management interface is ubiquitous from project initiation through project termination. It is reasonably presumed that business-project interfaces can exist at all work functions which require important decisions, approvals, reviews, and actions. To capture the data properly, the management interfaces between the business and project unit need to be identified at the work function level.

A capital project is a sizable and long-term capital investment that an industrial company undertakes to obtain fixed assets which create future economic benefits. Capital investment decisions have a long range impact on the company's performance and its shareholders' wealth. Business planning is the process during which the business case is prepared and culminates in the capital investment decision to fund a project. Business

planning includes corporate goal setting, strategic planning, market analysis, priority setting, opportunity identification, and capital budgeting (Dayananda et al. 2002).

Table 2.3 Work Functions with Business-project Interface

Phase/Process		Work Function
business planning		• Corporate Goal Setting • Strategic Planning • Market Analysis • Priority Setting • Opportunity Identification • Capital Budgeting
Front End Planning	**Feasibility Analysis**	• Financial Appraisal • Economic Feasibility Analysis • Technology Feasibility Analysis • Social Impact Analysis • Environmental Impact Analysis
	Concept Development	• Manufacturing Objectives Criteria • Business Objectives • Basic Data R&D • Project Scope • Value Engineering
	Detailed Scope	• Site Information • Procurement Strategy • Project Execution Plan
Project Execution		• Project Management • Estimating • Cost Management • Accounting • Scheduling • Communication • Management Information System • Risk Management • Contracting • Permitting • Funding Requests • Change Management • Health/Safety/Environment (HSE) • Claims Management • Quality Assurance/Quality Controls (QA/QC) • Human Resource Management • Detailed Engineering • Procurement • Construction • Startup/Commissioning
Project Close-out		• Project Close-out

Front end planning consists of three parts: feasibility analysis, concept development, and detailed scope (CII 1999). Feasibility analysis is usually conducted in terms of financial appraisal, economic feasibility analysis, technical feasibility analysis, social impact analysis, and environmental impact analysis. Concept development and

detailed scope are part of the project definition process. A capital project is usually defined in terms of basis of project definition, basis of design, and execution approaches. Among them, this research selected the project definition tasks which require business-project interaction. The basis for project definition consists of manufacturing objectives criteria, business objectives, basic data research and development, project scope, and value engineering. The design and execution approaches include site information, procurement strategy, and project execution plan (CII 1999).

Work functions in the project execution phase include project management, estimating, cost management, accounting, scheduling, communication, management information system, risk management, contracting, permitting, funding requests, change management, health/safety/environment (HSE), claims management, quality assurance/quality controls (QA/QC), human resource management, detailed engineering, procurement, construction, and startup/commissioning (CII 2007).

Project close-out is the last process in the project lifecycle. Close-out begins when the owner or user accepts the project deliverables, and the owner concludes that the project has met the goals that were established. Project close-out includes turnover of project deliverables to operations, redistributing resources such as staff, facilities, equipment, and automated systems, closing out financial accounts, recording and documenting project information and lessons learned, and planning for a post implementation review (Morrow 2011).

2.3. RESEARCH QUESTIONS AND PROPOSITIONS

Given the conceptual framework for identifying the business-project interface, the three research questions and propositions are addressed below. The research methodology is summarized as shown in Figure 2.5. Each proposition will be addressed in each chapter.

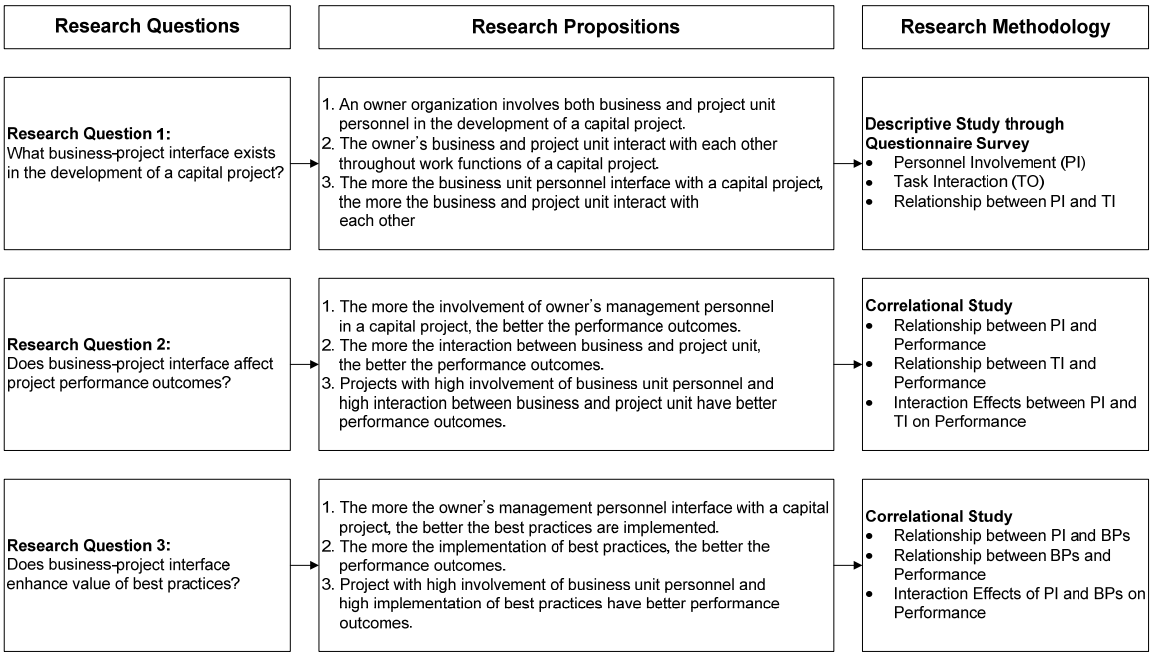


Figure 2.5 Research Questions, Propositions, and Research Methodology

Research Question 1: What business-project interface exists in the development of a capital project?

The first research question explains current states of the business to project interface that is in place during the development of a capital project. Until now, this interface has not been fully researched because the necessary quantitative information

pertaining to their interaction and involvement to accomplish project work functions was insufficient. For the purposes of this research, the business-project interface is comprised of the relationship between personnel involvement and task interaction. A survey was developed to measure this conceptual framework. The survey is explained in the research methodology section. Building from this research question, the current state of the business-project interfaces in the development of a capital project will be identified and quantified through descriptive study. The descriptive statistics of the business-project interface will be summarized in Chapter 4. To test this research question one, the following three research propositions are hypothetically established.

- *Proposition 1-1: An owner organization involves both business and project unit personnel in the development of a capital project.*
- *Proposition 1-2: The owner's business unit and project unit collaborate and interact with each other throughout the development of a capital project..*
- *Proposition 1-3: The more the business unit personnel interface on a capital project, the more the business unit and project unit interact with each other in order to accomplish critical tasks.*

Research Question 2: Does the business-project interface affect project performance outcomes?

While the first research question provides the quantitative information about the business-project interface in terms of personnel involvement and task interaction, the second research question tests the effects of the business-project interface on project

performance in terms of cost, schedule, change, and business performance. Project performance outcomes include common measures used for determining project success such as cost growth, schedule growth, change cost factor, and achievement of business objectives. This research question tests the impact of the business-project interface in terms of assessing the direct impacts of personnel involvement and task interaction, and by exploring their combined effects on performance outcomes. The direct impacts will be examined through simple correlation analysis using the phi coefficient, which is the correlation coefficient of the relationship between categorical variables. To show the combined effects, two-way factorial analysis of variance (ANOVA) will be applied. Task interaction will be used as an intervening variable to facilitate a better understanding of the relationship between personnel involvement and performance outcomes when the variables otherwise appear to not have a definite connection (de Vaus 2002). To test this research question, the following three research propositions are presumed.

- *Proposition 1: When owner management personnel are involved in a capital project, performance outcomes are better.*
- *Proposition 2: The greater the task level interaction between business and project units in a capital project, the better the performance outcomes.*
- *Proposition 3: Projects with high involvement of business unit personnel and high interaction between business and project units on certain tasks have better performance outcomes.*

Research Question 3: Does the business-project interface enhance the value of best practices?

Project management practices such as CII best practices were developed and implemented to measure management efforts to improve process and methods as well as performance outcomes (CII 2010). The value of these best practices has been proven by various CII Benchmarking & Metrics studies (CII 2003b, CII 2010). Several CII studies suggest that to achieve better implementation of best practices, both business executives and functional managers need to be involved, and in collaboration with project unit personnel (CII 2012). For the third research question, this research investigates the relationships between personnel involvement and best practices implementation, and tests if performance outcomes are improved when business unit personnel interface with a capital project and best practices are well-implemented. In this section, the relationships between personnel involvement and the implementation level of best practices and relationships between best practices implementation and performance outcomes through simple correlation using phi coefficient are investigated. In addition, the combined effects of personnel involvement and best practices implementation are tested through two-way ANOVA. To test this research question, the following three research propositions are assumed.

- *Proposition 1: When owner management personnel interface more on a capital project, best practices are more fully implemented.*
- *Proposition 2: Greater implementation of best practices leads to better performance outcomes.*

- *Proposition 3: Projects with high involvement of owner's management personnel and high implementation of best practices have better performance outcomes.*

To answer these research questions and propositions, the overall and detailed research methodology will be explained in the following chapter. The research structure summarizes the methodology holistically applied to this research. In later sections, the questionnaire development and survey instrument will be explained and then the data collection and validation procedure will be described.

CHAPTER 3: RESEARCH METHOLOGY

This chapter presents the overall research methodology. The research adopted a descriptive and correlational framework that supports a quantitative approach. First, this chapter explains structure of the research and how the study was conducted. Then, the questionnaire development is explained. Finally, this chapter explains the data collection and validation procedures and concludes with descriptive statistics that summarize the project data that were collected.

3.1 RESEARCH STRUCTURE

The study was conducted in three stages: research design, descriptive study of the business-project interface, and correlational study of its effects on project performance outcomes and value of best practices. As shown in Figure 3.1. Kerlinger (1986) defined a research design as a plan, with a structure and investigation strategy so conceived as to obtain answers to research question or problems. The research plan is the complete scheme or program of the research. It includes an outline of what the investigator will do from writing the hypotheses and their operational implications to the final analysis of data (Kerlinger 1986). Kumar (1999) suggested two main functions of a research design. The first relates to the identification and/or development of procedures and logistical arrangements required to undertake a study, and the second emphasizes the importance of quality in the procedures to ensure their validity, objectivity, and accuracy. In accordance with Kerlinger's definition, this research first developed a research design.

During the research design stage, the objectives and scope of the study were defined and existing interface studies were reviewed. Building upon the literature review, the conceptual framework for identifying business-project interfaces was developed and the research models and questions were established. To answer the research questions, the questionnaire was developed to obtain quantitative information on interfaces that exist between business and project unit personnel as they carry out project tasks that require their interaction.

The chapters of this dissertation are organized to answer the research questions Using data collected through the survey, a descriptive study was conducted to identify and quantify the business-project interface in terms of the involvement of business and project unit personnel and their task interaction at the work function level. In addition, the personnel and task interaction relationships were examined. Finally, the results of the descriptive study were validated by applying them to a personnel-work function relationship matrix. The findings will be explained in Chapter 4.

Once the identified business-project interface was validated, a correlational study was conducted to examine its effects on project performance outcomes. The effects can be investigated in terms of personnel involvement and task interaction. The interaction effects on project performance outcomes are also investigated. Detailed analysis results of the effects of the business-project interface on project performance outcomes will be described in Chapter 5.

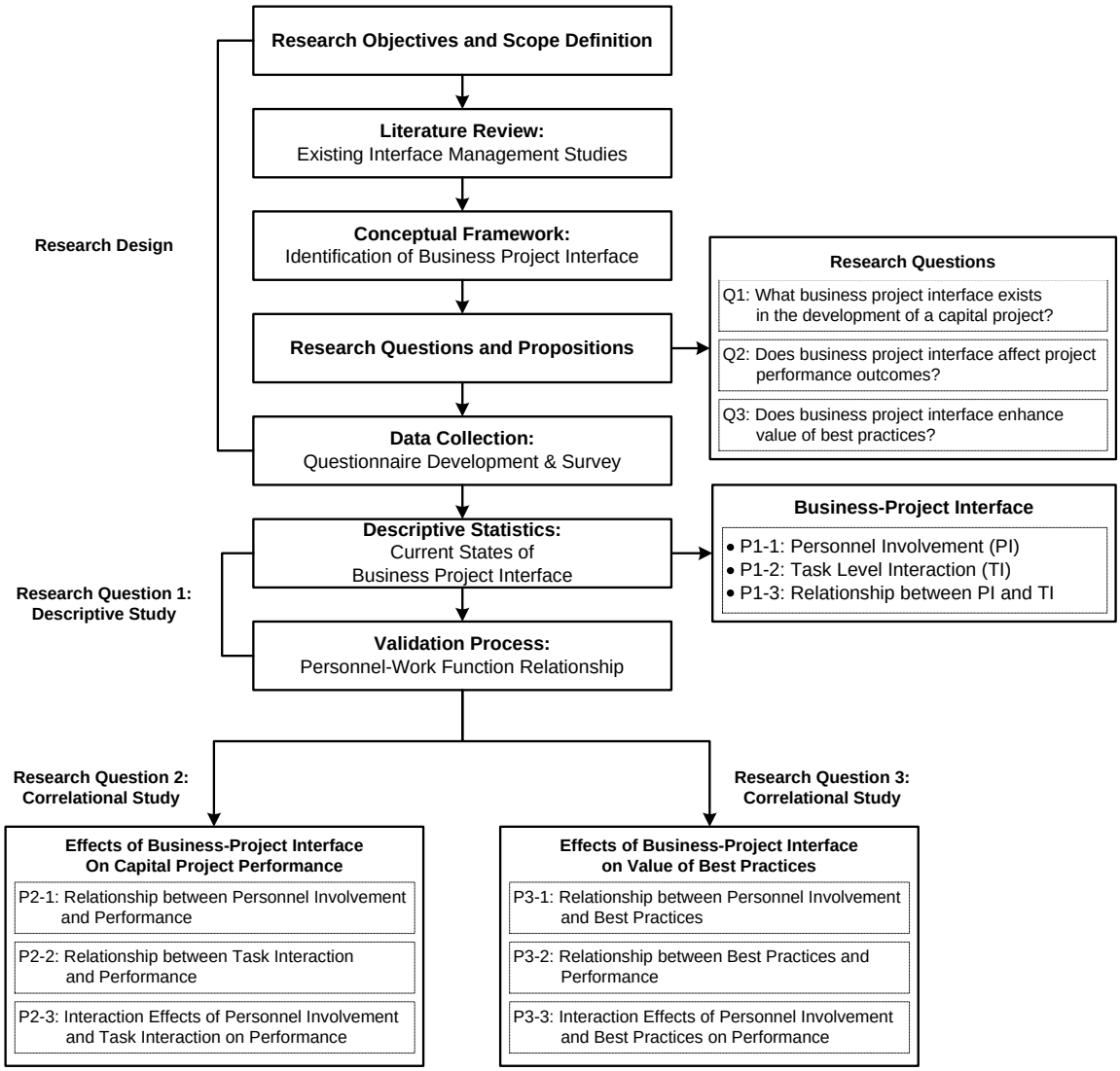


Figure 3.1 Research Structure

Finally, this research examines whether the business-project interface enhance value of best practices through correlational study. Best practices include Front End Planning, Alignment during Front End Planning, Partnering, Team Building, Project Delivery & Contract Strategy, Constructability, Project Risk Assessment, Change Management, Zero Accident Techniques, and Planning for Startup. The detailed analysis

results of the effects of business-project interface on value of best practices will be summarized in Chapter 6.

3.2 QUESTIONNAIRE DEVELOPMENT

The survey was developed to support a quantitative research method. As noted in the literature review, previous studies dealing with interface and its management were conducted through qualitative methods such as case studies, in-depth and focus group interviews. These interfaces have not been adequately recognized by the capital project industry and they can exist anywhere amongst two or more people, organizations, processes, systems, technologies, and methods. Due to the difficulty of interface research, most studies adopted a qualitative approach in order to identify business-project interfaces and issues which occur in the course of project execution, particularly during design and construction. Previous studies were limited because they dealt with unique and specific interfaces and their issues in a particular time frame.

The goal of the questionnaire was to quantify behavior found in the interface between the business and project unit management personnel. The CII Benchmarking & Metrics (BM&M) committee supported the development of the questionnaire and its validation by providing their expert suggestions and refinements. The units selected for analysis were determined based upon the conceptual framework. Twelve business units and eight project units were identified as likely to be involved in a capital project. Forty work functions were selected for inclusion. Three assessment tools were developed to capture the required data to support the investigation of the business-project interface.

3.2.1 Survey Instrument

The questionnaire captured quantitative and qualitative information about the organizational interface between the business and project units for the development and execution of a capital project. Three assessment tools, one each for personnel involvement, task interaction and influence factors. The personnel involvement assessment records the physical work-hours by which key personnel interact in each project development and execution phase and the degree of their involvement in the process. The task interaction assessment documents the major work functions where task interaction between business and project unit personnel occurs and their degree of interaction. The influence factors assessment explores extant organizational and process factors that may affect the personnel and their tasks. The developed questionnaire includes these influence factors affecting the business-project interface in terms of organization and process such as organizational culture and structure, communication norms, and the stage gate process. However, this dissertation does not include the findings of influence factors because most factors are derived from corporate level characteristics such as organizational culture and structure, and communication norm and its effectiveness. These influence factors could be presented in the future research. In summary, these tools quantitatively and qualitatively capture the important aspects of the internal organizational interface of an owner organization during the development and execution of a capital project. The questions for evaluating the business-project interface are summarized in Appendix A.

3.2.1.1 Personnel Involvement Assessment

The involvement of management personnel in a capital project can be quantified in terms of total work-hours and their phase time distribution. This research selected for measurement twenty management roles. The measure to assess the level of involvement is based on the approximate total work-hours, and their proportion of personnel involvement in each phase of the project. By capturing the data by phases, management participation can also be summarized at the project level. For example, if a project sponsor was involved with a project for approximately 100 work hours, and he or she spent 85% of those work hours on business planning, 10% on feasibility analysis, and 5% on conceptual development, then the involvement of the project sponsor would be recorded as shown in Table 3.1.

Table 3.1 Level of Measurement of Personnel Involvement

	Total Work-Hours				Phases/Processes					
						Front End Planning				
Management Personnel	0 Hours	1-40 Hours	41-400 Hours	401 + hours	Business Planning	Feasibility Analysis	Concept Development	Detailed Scope	Project Execution	Project Close-out
Project Sponsor	☐	☐	☒	☐	85%	10%	5%	0%	0%	0%

The sum of the percentages should equal 100 percent. This measurement approach identifies the key business and project personnel who are involved, their

approximate total work-hours and the proportion of their involvement throughout the project development and execution processes.

3.2.1.2 Task Interaction Assessment

To assess the level of task interaction during the development of a capital project, a measurement needs to first identify where the management interfaces exist between the business and project unit. The level of task interaction can be evaluated through the use of a two-part subjective judgment. The measurement first investigates whether business and project personnel interacted with each other on a given work task and then assesses the level of interaction using a 0-5 scale, as shown in Table 3.2.

Table 3.2 Measurement of Level of Task Interaction

Example: Planning and Execution Tasks	Unit Involvement		Level of Interaction							
	Business	Project	0	1	2	3	4	5	N/A	D/K
Project Scope Definition	☒	☒	☐	☐	☐	☒	☐	☐	☐	☐

0 - No Interaction
1 - Very Poor Interaction
2 - Poor Interaction
3 - Moderate Interaction
4 - Good Interaction
5 - Very Good Interaction
N/A - Not Applicable
D/K – Don't Know

Respondents assessed their level of task interaction by referring to the definitions provided in Table 3.3, ranging from "No Interaction" at Level 0 to "Very Good Interaction" at Level 5. Specifically, this research examines both the nature of the interaction itself and the strength of its influence in driving the project toward its business and technical objectives.

Table 3.3 Definition of Level of Interaction

Level	Linguistic Expression	Definition
Level 0	No Interaction	• No involvement amongst business and project personnel
Level 1	Very Poor Interaction	• Rare and involuntary collaboration amongst personnel
Level 2	Poor Interaction	• Occasional and involuntary collaboration amongst personnel
Level 3	Moderate Interaction	• Occasional and voluntary collaboration amongst personnel
Level 4	Good Interaction	• Frequent and voluntary collaboration amongst personnel
Level 5	Very Good Interaction	• Continuous and voluntary collaboration amongst personnel

The definition for each scale was defined considering both quantitative and qualitative aspects of task interaction. The definitions for each quantitative aspect can be measured as the frequency of task interaction. The qualitative aspect can be measured as the spontaneity of task interaction and is included in the definition for each level. For example Level 2, "Poor Interaction" is defined as "occasional and involuntary collaboration amongst personnel" whereas Level 4, "Good Interaction" is defined as "frequent and voluntary collaboration amongst personnel." Task interaction includes all types of organizational interaction such as meetings, conference calls and e-mail.

3.2.1.3 Personnel-Work Function Relationship Matrix

The questionnaire for identifying business-project interface does not include questions specifically about task level participation of management personnel because it was impractical for this study to capture the data at that level due to differences in how various companies track and report such hours. To capture the necessary data, this research developed the personnel-work function relationship matrix. This portion of the

questionnaire asks about the work functions that management personnel typically participated in during the development of a capital project. This includes reporting on work-hours for activities such as meetings, phone calls, faxes, e-mail, monitoring, supervising, documentation, and review and approval of requests. The relationships identified from this inquiry will be used to validate the relationship between personnel involvement and task interaction in Chapter 4.

3.2.2 CII Benchmarking & Metrics Database

To quantify and measure performance outcomes, this research used the CII BM&M questionnaire (version 10.3). The CII BM&M project survey is web-based questionnaire located within the CII Performance Assessment System. The Performance Assessment System consists of five parts which are designed for collecting project information including general descriptive, performance, practice, engineering productivity, and construction productivity sections. The CII BM&M questionnaire was developed by CII BM&M committee members who include academic researchers and industrial experts from CII member companies which are comprised of leading owners and contractors in the capital project industry. From that data set, this research used project data including descriptive project characteristics, performance measurements, and use of best practices.

The performance of a capital project has been traditionally measured in terms of cost, schedule, and quality. In recent years, the scope of performance measurement has

extended into various performance areas according to organizational goals and objectives such as safety, productivity, change, business, etc (Suk, 2012). Best practices endorsed by the Construction Industry Institute (CII) are processes or methods that, when executed effectively, leads to enhanced project performance. They have been proven through extensive industry use and/or validation.

3.2.2.1 Project Performance Outcomes

Table 3.4 summarized the definition of performance metrics. As shown in Table 3.4, project performance is quantified by performance metrics in terms of cost, schedule, change, and business objectives. Among various performance metrics suggested by CII, cost and schedule metrics are most widely used by various construction studies to measure project performance outcomes. These metrics are measured through comparison of actual value to the originally estimated value. Consequently, a smaller value represents better performance for cost and schedule growth metrics. In a capital project, changes are inevitable and typically occur during project execution. When a change occurs, the scope of a project is changed or modified. Thus, the change performance measure is an intermediate outcome of the project and is reflective of the quality of the scope definition in front end planning and scope management during execution. Change performance is measured through the change cost factor which is defined as the proportion of the total cost of changes to the actual total project cost. Similarly, a smaller change cost factor value indicates better change performance.

Business performance is measured through a metric that records the level of achievement of business objectives. Business performance is not easily measured objectively because it deals with how project outcomes align with business strategy. Thus, the achievement of business objectives is measured on a Likert scale and is answered according to the respondent's perception about the extent to which the project achieved its business objectives. In this metric, a higher value on the scale represents better performance.

Table 3.4 Definition of Performance Metrics

Performance Metric		Metric Definition
Cost	Project Cost Growth	$\frac{\text{Actual Total Project Cost – Initial Predicted Project Cost}}{\text{Initial Predicted Project Cost}}$
Schedule	Project Schedule Growth	$\frac{\text{Actual Total Project Duration – Initial Predicted Project Duration}}{\text{Initial Predicted Project Duration}}$
Change	Change Cost Factor	$\frac{\text{Total Cost of Changes}}{\text{Actual Total Project Cost}}$
Business	Achievement of Business Objectives	Not at All Successful … Moderately … Extremely Successful 1 2 3 4 5 6 7

3.2.2.2 Best Practice Implementation Scores

The CII best practices were adapted to measure the management effort to improve processes and methods as well as performance outcomes. Through CII's research on industry processes and methods, CII has developed various best practices, and most of them have been widely adopted by the capital project industry (CII 2010). Among them,

this research focuses on ten project-level Best Practices: front end planning, Alignment during front end planning, Partnering, Team Building, Project Delivery and Contract Strategy, Constructability, Project Risk Assessment, Change Management, Zero Accident Techniques, and Planning for Startup. The definitions of Best Practices that are examined in this research are summarized in Table 3.5 and the project-level questions for the assessment of the implementation of Best Practices are parts of CII benchmarking questionnaire.

Each best practice is quantified through a specific scoring algorithm developed by the CII benchmarking and metrics committee. The formula for calculating the score of each Best Practice is presented below:

$$\text{Best Practice Score} = \frac{\sum_{i=1}^{n} S_i \times W_i}{\sum_{i=1}^{n} W_i}$$

Where, S_i means the score of question i, and W_i means the weight of question i.

During the development of the questions for the practices, industry experts assigned weights for individual questions based on their perceived relative importance. There are several questions in each of the best practices sections and they are posed in several different formats including Likert scale, multiple choice, and yes or no. The weights were assigned to answers according to question formats. This algorithm allowed the best practice scores to be calculated so that they represent the implementation level of each Best Practice. Best Practice scores range from 0 (virtually not used) to 10 (extremely well implemented).

Table 3.5 Definitions of CII Best Practices (CII, 2012)

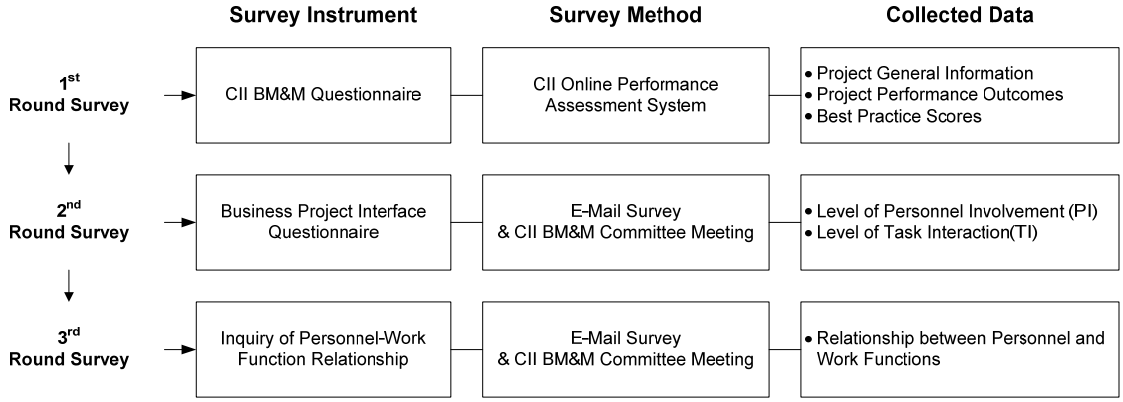
Practices	Definition	Remark
Front End Planning	The process of developing sufficient strategic information such that owners can address risk and decide to commit resources to maximize the chance for a successful project. Front-End Planning includes putting together the project team, selecting technology, selecting the project site, developing project scope, and developing project alternatives. Front-End Planning is often perceived as synonymous with front-end loading, pre-project planning, feasibility analysis, and conceptual planning.	All projects
Alignment during FEP	Alignment is the condition where appropriate project participants are working within acceptable tolerances to develop and meet a uniformly defined and understood set of project objectives.	"
Partnering	A commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources. This requires changing traditional relationships to a shared culture without regard to organizational boundaries. The relationship is based on trust, dedication to common goals and an understanding of each other's individual expectations and goals.	"
Team Building	A formal project-focused process that builds and develops shared goals, interdependence, trust and commitment, and accountability among team members and that seeks to improve team members' problem-solving skills	"
Project Delivery and Contract Strategy	A structured process of evaluating and prioritizing owner's objectives, reviewing and evaluating delivery methods and contract types, and then determining what is the appropriate delivery method and contract type for this project.	For only owner projects
Constructability	The effective and timely integration of construction knowledge into the conceptual planning, design, construction and field operations of a project to achieve the overall project objectives in the best possible time and accuracy, at the most cost-effective levels.	All projects
Project Risk Assessment	The process to identify, assess and manage risk. The project team evaluates risk exposure for potential project impact to provide focus for mitigation strategies.	"
Change Management	The process of incorporating a balanced change culture of recognition, planning and evaluation of project changes in an organization to effectively manage project changes.	"
Zero Accident Techniques	Site specific safety programs and implementation, and auditing and incentive efforts to create a project environment and a level of training that embraces the mindset that all accidents are preventable, and that zero accidents are an obtainable goal.	"
Planning for Startup	Startup is the transitional phase between plant construction completion and commercial operations, including all of the activities that bridge these two phases. Planning for Startup consists of a sequence of activities that begins during requirements definition and extends through initial operations. This section assesses the level of Startup Planning by evaluating the degree of implementation of specific activities throughout the various phases of a project.	For only Industrial Projects

3.3 DATA COLLECTION AND VALIDATION

This section explains the data collection and validation in this research. An outline of the data collection procedures are presented first, and then the data validation process is explained.

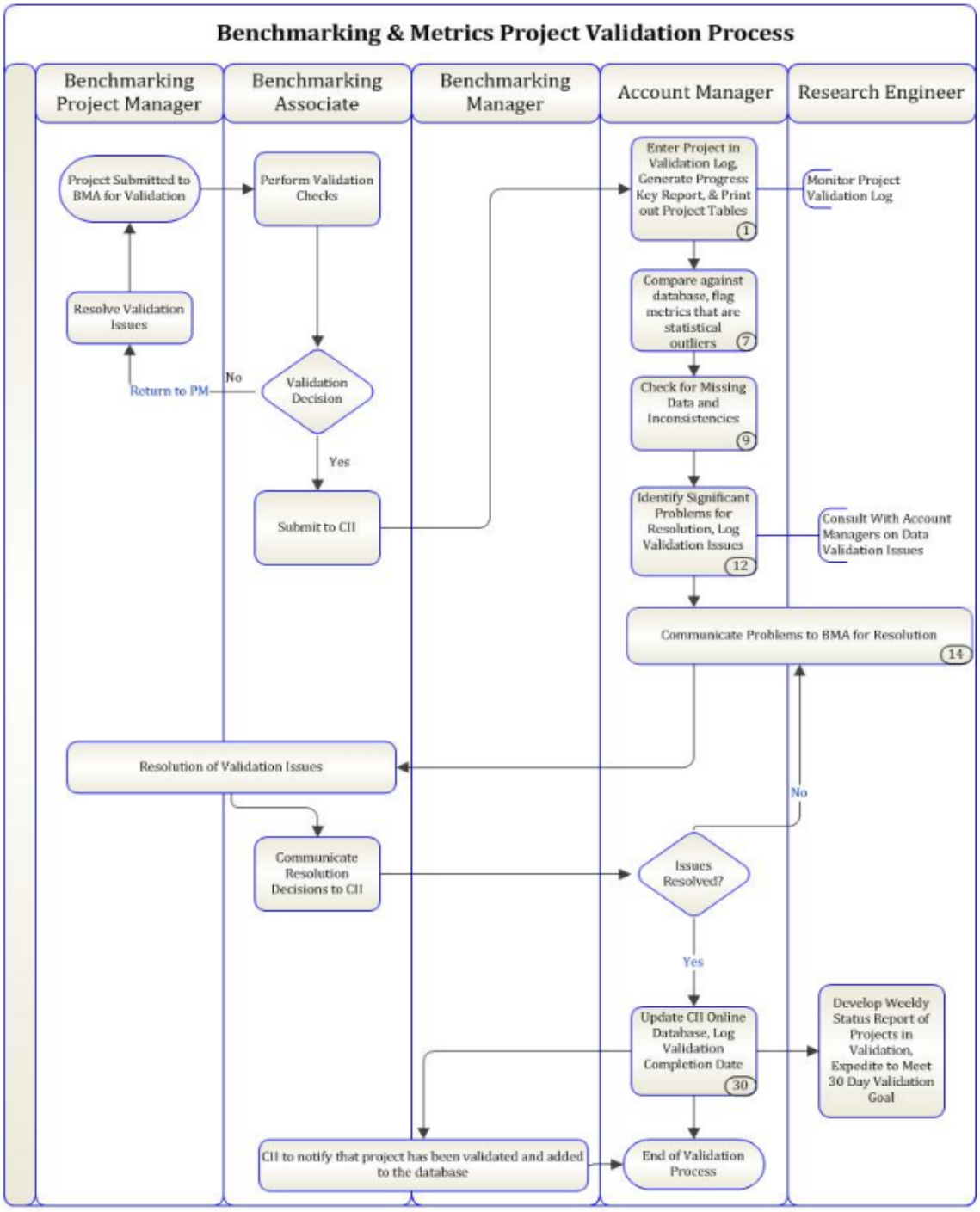
The data for this research were collected over the course of three rounds of questionnaire surveys, as can be seen in Figure 3.2. The first round survey was conducted through the CII BM&M questionnaire from 2007 to 2010. In this round, capital project data were collected on general project information, performance, and practices. During this round, 183 projects from CII owner companies were collected. Next, the questionnaire developed by this research to investigate the business-project interface was disseminated to representatives from the 183 owner capital projects from June 2011 to May 2012. A total of 42 project data responses were received. The second round survey collected data about personnel involvement and task interaction. The data for personnel involvement included total work-hours, phase participation, and phase time distribution. The data for task interaction were collected in terms of task level collaboration and interaction between the business and project units throughout a project life cycle. Finally, the third round survey was conducted to obtain an assessment of the task level involvement of management personnel through an inquiry of the relationship between personnel and work functions. The data collected in the third round of the survey were used to validate relationships between personnel interaction and task interaction on the interface between business and project units.

Figure 3.2 Data Collection Procedures



To validate the collected data, this research adopted the CII BM&M project validation process. As usual, the project data collected through the CII Online Performance Assessment System were validated by the CII BM&M account managers. They ensure the reliability and validity of the data provided about the projects. The project data were validated through an interactive collaboration with data liaisons who submitted project data into the system as can be seen in Figure 3.3. The data collected through the second and third round survey were validated following the same process.

Figure 3.3 CII Benchmarking & Metrics Project Validation Process



3.4 DESCRIPTIVE STATISTICS OF PROJECT DATA

3.4.1 Project Characteristics

At the conclusion of data collection, a total of 42 projects had been completed by representatives from 9 CII owner member companies. Figure 3.4 describes the major features of the project data collected for this research. Among the 42 projects collected through the survey, 28 projects (67%) were from companies in light industry, and 14 projects (33%) were from heavy industry. In other categories, the responses were well-distributed. In terms of the facilities delivered by each project, there were 18 light industrial facilities (43%), 14 were heavy industrial facilities (33%), and 10 were building facilities (24%). The responses were also relatively equally distributed concerning the nature of each project. Grass Roots and modernization projects accounted for 38% and 33%, respectively, while the remainder, 29% were identified as additions. Sixty-nine percent of the projects were executed in the United States. As shown in Table 3.6, the average Total Installed Cost ($TIC) of all projects was $70.8 million and the average duration was 130 weeks. The $TIC was adjusted for inflation and location. The majority of the sampled projects had a $TIC of over $5 million. Projects costing $5-50 million accounted for 41% of the responded projects, followed by projects costing over $50 million (33%). Projects costing less $5 million accounted for 26%.

Table 3.6 Descriptive Statistics: Average TIC and Project Duration

	All	< $5MM	$5MM - $50MM	> $50MM
Sample Size (N)	42	11	17	14
Avg. $TIC	$70.8 MM	$1.1 MM	$28.0 MM	$177.5 MM
Avg. Project Duration	130 weeks	57 weeks	134 weeks	181 weeks

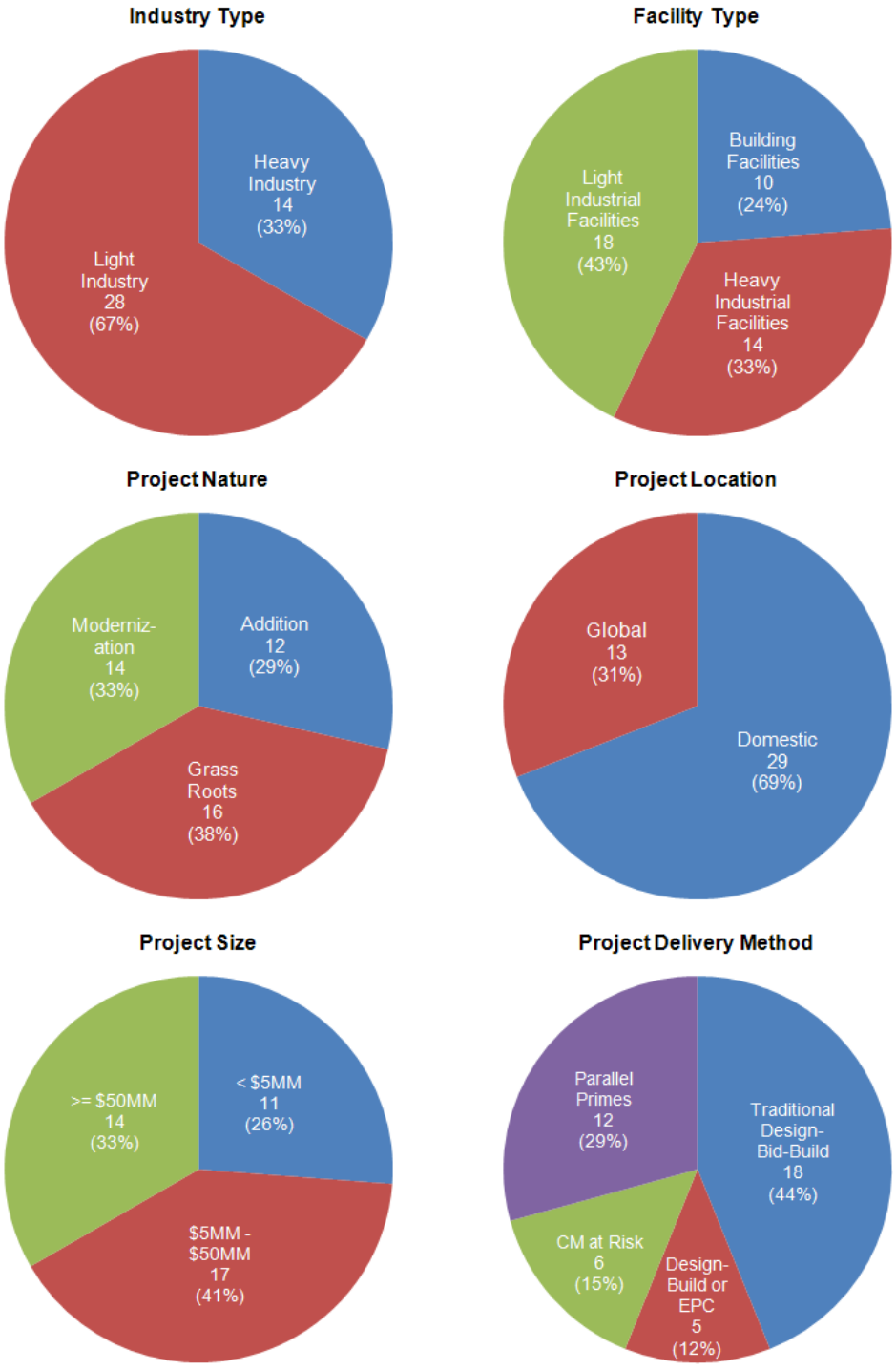


Figure 3.4 Distributions of Responses by Project Characteristics

The project delivery methods most frequently used by the projects were Traditional Design-Bid-Build and Parallel Prime, accounting for 44% and 29% of the total number of projects collected. These methods were followed by Construction Management (CM) at Risk (15%), and Design Build or EPC (12%).

As illustrated in Figure 3.5, the distribution of project complexity reported by the sampled projects is presented in Figure 3.5. Projects with a higher complexity level (> 6) accounted for 19% of the total. Projects reporting a moderate level of complexity (3-5) accounted for 60%. Projects with lower complexity (< 2) accounted for 21%.

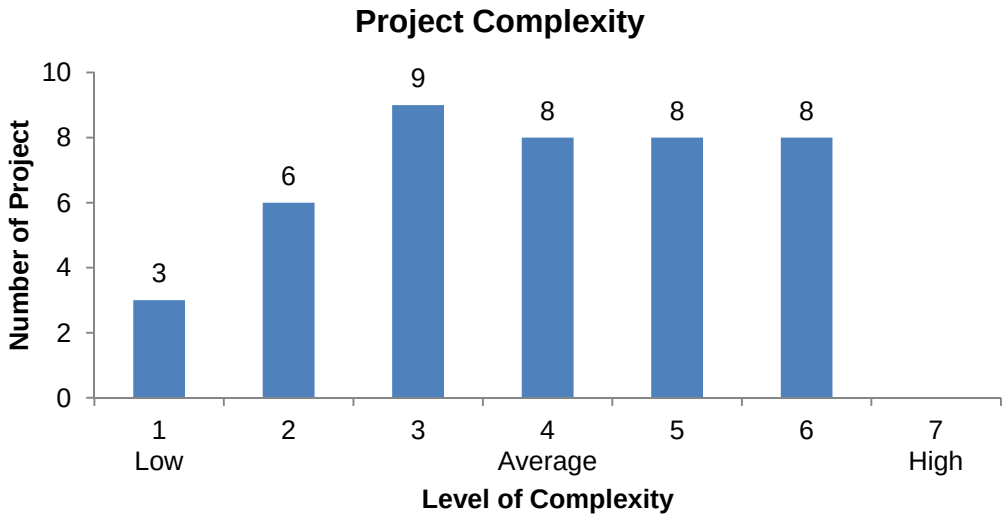


Figure 3.5 Number of Project by Project Complexity

3.4.2 Performance Outcomes

Table 3.7 summarizes the descriptive statistics calculated for project performance. Based on the overall mean values, projects in the data sets show an average -2.6% project cost growth, 9.7% project schedule growth, 3.9% change cost factor, and 6.32 for achievement of business objectives on a 7-point Likert scale. In other words, the descriptive statistics indicate that on average, the projects were within budget by -2.6%, were behind estimated schedule by 9.7%, and spent 3.9% of total installed cost on changes. In addition, the data liaisons perceived that on average the projects achieved business objectives.

Table 3.7 Descriptive Statistics: Performance

	All			< $5MM			$5MM-$50MM			> $50MM		
Performance	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
Project Cost Growth	41	-0.026	0.135	11	-0.152	0.225	17	-0.048	0.098	13	-0.006	0.067
Project Schedule Growth	39	0.097	0.196	11	0.151	0.329	15	0.088	0.118	13	0.061	0.104
Change Cost Factor*	39	0.039	0.041	11	0.053	0.048	16	0.046	0.042	12	0.016	0.018
Achievement of Business Objectives	25	6.320	1.282	N.A.			14	0.936	0.095	11	0.855	0.257

* indicate p-value is less than 0.1. N.A. means there is no data to calculate the statistic.

3.4.3 Best Practices

Table 3.8 summarizes the descriptive statistics for CII best practice implementation scores. The mean value shows the average levels reported for their implementation. In the data set, the implementation levels were found to be higher in the planning-related best practices such as front end planning, Alignment during front end planning, and Planning for Startup, and the execution-related best practices such as

Change Management and Zero Accident Techniques. In contrast, the implementation levels for organization-related best practices such as Partnering and Team Building were relatively lower. Interestingly, their standard deviation values were higher, indicating a wide disparity among the projects on use of these best practices.

Table 3.8 Descriptive Statistics: Best Practice Scores

	All			$5MM-$50MM			> $50MM		
Best Practice	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
Front End Planning	25	7.560	1.319	15	7.496	1.323	10	7.658	1.379
Alignment during Front End Planning	27	6.954	1.445	15	6.868	1.674	12	7.061	1.161
Partnering	24	3.043	3.304	13	2.493	3.502	11	3.693	3.088
Team Building	25	2.097	3.647	13	1.432	3.496	12	2.818	3.820
Project Delivery and Contract Strategy	22	4.625	3.508	12	4.101	3.776	10	5.255	3.236
Constructability	24	4.445	2.589	13	4.095	3.125	11	4.859	1.831
Project Risk Assessment	23	5.655	3.012	12	5.148	3.275	11	6.209	2.741
Change Management	24	8.696	0.998	13	8.611	1.022	11	8.796	1.009
Zero Accident Techniques*	24	6.885	1.277	13	6.431	1.482	11	7.421	0.729
Planning for Startup	22	7.506	1.260	10	7.460	1.234	12	7.544	1.336

It should be noted that the data collected through this survey do not represent the entire construction industry because survey respondents were all CII members, who are considered leading owner companies in the construction industry. Most CII members actively adopt and implement best practices endorsed by CII. These best practices are processes or methods that, when executed effectively, have been proven to lead to enhanced project performance. Therefore, the capital project performance outcomes of CII members are usually better than the overall industry average.

CHAPTER 4: CURRENT STATE OF BUSINESS-PROJECT INTERFACE

This chapter presents a quantitative account of the nature of the business-project interface during the development of capital projects. This was accomplished by confirming the first research question, "What business-project interface exists in the development of a capital project?" This current state of business-project interface was measured in terms of personnel involvement and task interaction. Next, the relationships between personnel involvement and task interaction are examined. The relationships established in the previous step are then validated against the personnel-work function relationship matrix. Finally, the task level business-project interfaces are identified and summarized.

4.1 PERSONNEL INVOLVEMENT

This section presents the investigation into the involvement of management personnel who participate in the development of a capital project. To identify and quantify the business-project interface, the involvement of owner's management personnel needs to be measured. In order to understand the interfaces that exist between the business and project units, it was first necessary to identify who participated and how much time they spent on the project. For this, this section presumes the first research proposition of research question one as follow:

Proposition 1-1: An owner organization involves both business and project unit personnel in the development of a capital project.

For test this proposition, this research identified 20 management personnel roles who were selected based on the conceptual framework for identifying the business-project interface and their involvements were measured through personnel involvement assessment using questionnaire survey. For measuring personnel involvement, the following four attributes were investigated: project level involvement, phase level involvement, phase time distribution, and earliest participation point.

4.1.1 Project Level Involvement

The 20 management roles were classified into three groups: senior management personnel, functional management personnel, and project management personnel. Table 4.1 presents the level of involvement of management personnel as a frequency of their total work-hours at the project level.

Among senior management personnel, the project sponsor was most likely to be involved in a capital project (92.9%), followed by the business unit manager (71.4%). Project sponsors were also found to spend more time on capital project development than business unit managers. While half of the project sponsors reported spending more than 40 work-hours on the project, slightly more than half (54.8%) of business unit managers reported spending only from 1-40 work-hours on the project. Only 14.3% of the capital projects reported any involvement from chief executive officers.

Table 4.1 Project Level Involvement of Management Personnel (N=42)

Management Personnel		Not Participated	Participated		
		0 hour	1 ~ 40 hours	41- 400 hours	> 400 hours
Senior Management Personnel	Chief Executive Officer	85.7%	11.9%	2.4%	0.0%
	Business Unit Manager	28.6%	54.8%	14.3%	2.4%
	Project Sponsor	7.1%	42.9%	38.1%	11.9%
Functional Management Personnel	Accounting Manager	50.0%	23.8%	19.0%	7.1%
	Finance Manager	31.0%	38.1%	26.2%	4.8%
	Marketing/Sales Manager	85.7%	11.9%	2.4%	0.0%
	Human Resource Manager	83.3%	7.1%	9.5%	0.0%
	Information Technology Manager	59.5%	21.4%	16.7%	2.4%
	Facility/Plant Manager	14.3%	40.5%	38.1%	7.1%
	Contract & Legal Manager	7.1%	61.9%	28.6%	2.4%
	Operations/ Production Manager	11.9%	33.3%	45.2%	9.5%
	Portfolio/Program Manager	54.8%	21.4%	19.0%	4.8%
Project Management Personnel	Project Manager	0.0%	0.0%	19.0%	81.0%
	Project Controls Manager	4.8%	28.6%	26.2%	40.5%
	Engineering Manager	14.3%	26.2%	40.5%	19.0%
	Engineering Team Lead	14.3%	4.8%	33.3%	47.6%
	Procurement Manager	2.4%	35.7%	52.4%	9.5%
	Construction Manager	11.9%	0.0%	26.2%	61.9%
	QA/QC Manager	28.6%	31.0%	16.7%	23.8%
	HSE Manager	14.3%	14.3%	47.6%	23.8%

Among functional management personnel, the contract/legal manager was most frequently involved, (92.9%), followed by the operations/production manager (88.1%), the facility/plant manager (85.7%), and the finance manager (69.0%). More than 50% of these functional managers spent from 1-400 work-hours on the projects: contract/legal manager (90.5%), operations/production manager (78.5%), facility/plant manager (78.6%), and finance manager (64.3%). In the meantime, half of the responses reported the involvement of the accounting manager (50%), portfolio/program manager (45.2%),

and the information technology manager. Other roles, such as the marketing/sale manager (14.3%) and the human resource manager (16.7%) were found to participate only rarely in capital project development.

As to be expected, 100 percent of the project management personnel were involved in the project. Other project-related roles also revealed high levels of participation including the procurement manager (97.6%), project controls manager (95.2%), construction manager (88.1%), engineering manager (85.7%), engineering team lead (85.7%), HSE manager (85.7%), and QA/QC manager (71.4%).

Table 4.2 presents the median for management-level involvement by cost category. Total project work-hours are usually correlated with project size and this research examined that relationship. Project size was categorized into three cost categories: <$5MM, $5MM ~ $50MM, and >$50MM. The total work-hours for most project management personnel were found to be positively correlated with total project cost at the 95% significance level, except for the HSE manager, at the 90% significance level. Among senior management personnel, only the project sponsor was found to be significantly correlated with project size at the 95% significance level. Among the functional management personnel, total work-hours for human resource managers and information technology managers were significantly correlated with project size at the 95% significance level, and accounting managers and finance managers work-hours were significantly correlated with project size at the 90% significance level.

The chief executive officer, marketing/sales manager, and human resource manager tended to be rarely involved during the capital project. The information

technology manager tended to be involved in large-size projects costing greater than $5MM. The portfolio/program manager was found to be more involved in smaller projects (< $5MM) than in large size projects (> $5MM).

Table 4.2 Median of Personnel Involvement by Cost Category

Management Personnel		All (N=42) Median	Cost Category < $5MM (N=11) Median	$5MM-$50MM (N=17) Median	> $50MM (N=14) Median
Senior Management Personnel	Chief Executive Officer	0 hours	0 hours	0 hours	0 hours
	Business Unit Manager	1-40 hours	1-40 hours	1-40 hours	1-40 hours
	Project Sponsor**	1-40 hours	1-40 hours	41-400 hours	41-400 hours
Functional Management Personnel	Accounting Manager*	0 hours	0 hours	1-40 hours	0 hours
	Finance Manager*	1-40 hours	1-40 hours	1-40 hours	41-400 hours
	Marketing/Sales Manager	0 hours	0 hours	0 hours	0 hours
	Human Resource Manager**	0 hours	0 hours	0 hours	0 hours
	Information Technology Manager**	0 hours	0 hours	0 hours	1-40 hours
	Facility/Plant Manager**	1-40 hours	1-40 hours	41-400 hours	41-400 hours
	Contract/Legal Manager	1-40 hours	1-40 hours	1-40 hours	1-40 hours
	Operations/ Production Manager	41-400 hours	1-40 hours	41-400 hours	1-40 hours
	Portfolio/Program Manager	0 hours	1-40 hours	0 hours	0 hours
Project Management Personnel	Project Manager**	> 400 hours	41-400 hours	> 400 hours	> 400 hours
	Project Controls Manager**	41-400 hours	41-400 hours	41-400 hours	> 400 hours
	Engineering Manager**	41-400 hours	1-40 hours	41-400 hours	41-400 hours
	Engineering Team Lead**	41-400 hours	41-400 hours	41-400 hours	> 400 hours
	Procurement Manager**	41-400 hours	1-40 hours	41-400 hours	41-400 hours
	Construction Manager**	> 400 hours	41-400 hours	> 400 hours	> 400 hours
	QA/QC Manager**	1-40 hours	0 hours	1-40 hours	41-400 hours
	HSE Manager*	41-400 hours	41-400 hours	41-400 hours	41-400 hours

* indicate *p*-value is less than 0.1 and ** indicates *p*-value is less than 0.05

4.1.2 Phase Level Involvement

4.1.2.1 Phase Level Participation

This research study also examined the phase level involvement of management personnel starting from business planning to project close-out. Figure 4.3 summarizes the phase level participation reported by management personnel. Findings are presented below.

Among senior management personnel, more than 50% of respondents reported project sponsor participation in all phases of the project life cycle. In contrast, the business unit manager mainly participated in business planning.

Among the function management personnel, it was reported by more than 50% of the responses that the facility/plant manager, operations/production managers, and contract/legal manager participated in front end planning and project execution.

Among the project management personnel, the project manager, project controls manager, engineering manager, and engineering team lead participated earlier than other project management personnel. For example, the procurement manager, construction manager, QA/QC manager, and HSE manager participated in phases after feasibility analysis.

Table 4.3 Phase Level Participation of Management Personnel

Management Personnel		Business Planning		Front End Planning						Project Execution		Project Close-out	
				Feasibility Analysis		Concept Development		Detailed Scope					
		N	%	N	%	N	%	N	%	N	%	N	%
Senior Management Personnel	Chief Executive Officer	6	17%	3	8%	1	3%	1	3%	1	3%	0	0%
	Business Unit Manager	22	61%	13	36%	11	31%	9	25%	9	25%	1	3%
	Project Sponsor	30	83%	30	83%	28	78%	23	64%	25	69%	10	28%
Functional Management Personnel	Accounting Manager	11	31%	12	33%	11	31%	4	11%	8	22%	10	28%
	Finance Manager	15	42%	17	47%	15	42%	7	19%	9	25%	10	28%
	Marketing/Sales Manager	6	17%	1	3%	1	3%	1	3%	1	3%	1	3%
	Human Resource Manager	6	17%	5	14%	5	14%	4	11%	6	17%	2	6%
	Information Technology Manager	3	8%	10	28%	13	36%	13	36%	16	44%	9	25%
	Facility/Plant Manager	25	69%	27	75%	29	81%	24	67%	30	83%	23	64%
	Contract & Legal Manager	8	22%	21	58%	20	56%	18	50%	22	61%	11	31%
	Operations/ Production Manager	15	42%	23	64%	28	78%	18	50%	20	56%	15	42%
	Portfolio/Program Manager	16	44%	17	47%	14	39%	15	42%	15	42%	11	31%
Project Management Personnel	Project Manager	23	64%	29	81%	35	97%	36	100%	36	100%	36	100%
	Project Controls Manager	12	33%	15	42%	25	69%	30	83%	33	92%	31	86%
	Engineering Manager	20	56%	28	78%	35	97%	34	94%	34	94%	28	78%
	Engineering Team Lead	3	8%	19	53%	33	92%	34	94%	35	97%	27	75%
	Procurement Manager	3	8%	11	31%	20	56%	30	83%	28	78%	15	42%
	Construction Manager	2	6%	5	14%	15	42%	30	83%	30	83%	18	50%
	QA/QC Manager	1	3%	12	33%	18	50%	22	61%	24	67%	18	50%
	HSE Manager	11	31%	17	47%	24	67%	26	72%	29	81%	18	50%

Sample Size is 36.

It was shown in the CII RT 241 (2006) that early participation by project management personnel is important to achieving alignment in project goals and objectives. The earlier they participate in a project, the better this alignment can be achieved. Because of its importance, the earliest point when project management personnel participated in the project was captured by this research. Figure 4.1 shows the frequency of the earliest participation point for project management personnel. Business planning was most frequently reported as the earliest participation point for the project manager, project controls manager, engineering manager, and the HSE manager. Feasibility analysis was most frequently reported as the earliest participation point for the engineering team lead and the QA/QC manager. Detailed scope was most frequently reported as the earliest participation point for the procurement manager and the construction manager.

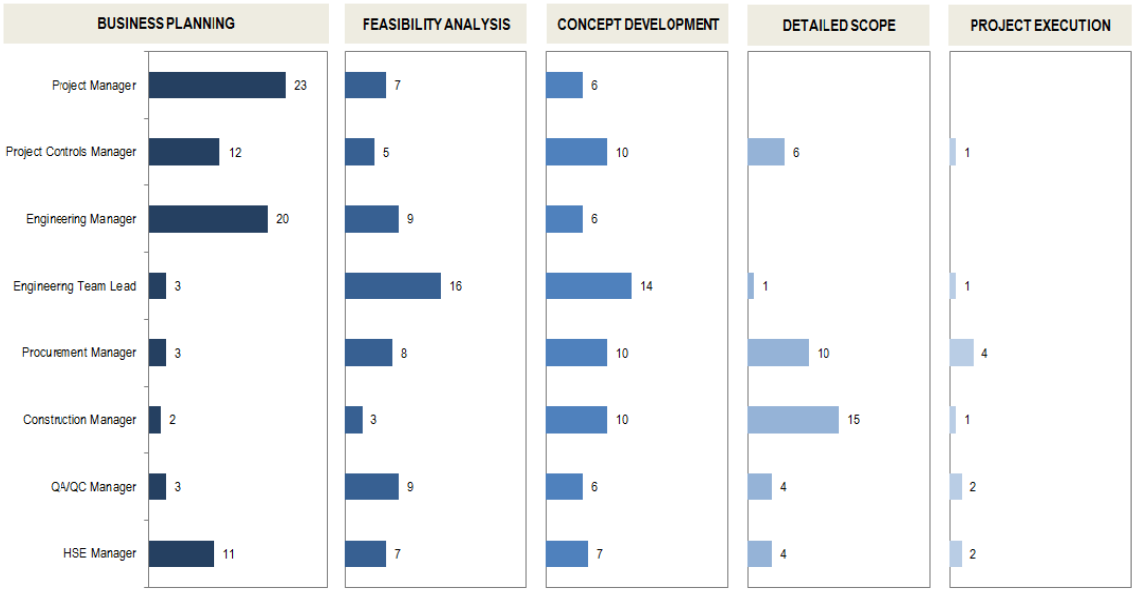


Figure 4.1 Earliest Participation Point of Project Unit Personnel

4.1.2.2 Phase Level Time Distribution

This research also investigated the distribution of work-hours of management personnel by phase. The work-hour distribution only includes personnel who were actually involved in the project. Figure 4.2 presents the average management personnel work-hours distribution for each phase. The box-plots representing time distribution are summarized in Appendix D.

It was found that senior management personnel were most involved during the planning phases. Chief executive officers spent 82% of their work-hours during business planning. Business unit managers reported that an average 63% of their work-hours were spent during business planning and 31% during front end planning. Project sponsors spent 32% of work-hours during business planning, and 52% during front end planning.

The phase time distributions of functional management personnel varied, depending on their roles and responsibilities during the development of the project. Accounting managers, finance managers, and the marketing/sales manager were most involved during planning. Accounting managers spent 23% of their work-hours during business planning, 46% on front end planning, and 31% over the course of project execution. Finance managers spent 36% of their work-hours on business planning, 44% on front end planning, and 19% for project execution. Marketing/sales managers were found to spend most of their work-hours on Business planning, 87%, 11% on front end planning, and only 3% during project execution.

Human resources managers spread their time across all phases of the project and spent 23% of their work-hours on business planning, 46% on front end planning, and

31% during project execution. Information Technology Managers spent only 2% of their work-hours on business planning, 49% on front end planning, and 49% for project execution. Facility/plant managers reported 26% of their work-hours for business planning, 46% on front end planning, and 28% on project execution. Contract/legal managers spent 8% of their work-hours on business planning, 54% on front end planning, and 39% on project execution. Operations/production managers spent 13% of their work-hours on business planning, 55% for front end planning, and 32% for project execution. Portfolio/program managers reportedly spent 23% of their work-hours on business planning, 53% for front end planning, and 24% during project execution.

Project management personnel usually spent most their time on front end planning and project execution as shown in Figure 4.2. Project managers and engineering and procurement managers all reported spending more time on front end planning than project execution. On the other hand, construction managers and control managers spent more time on project execution than front end planning. In particular, project controls managers and the engineering manager reported that they spent only about 10% of their work-hours on business planning.

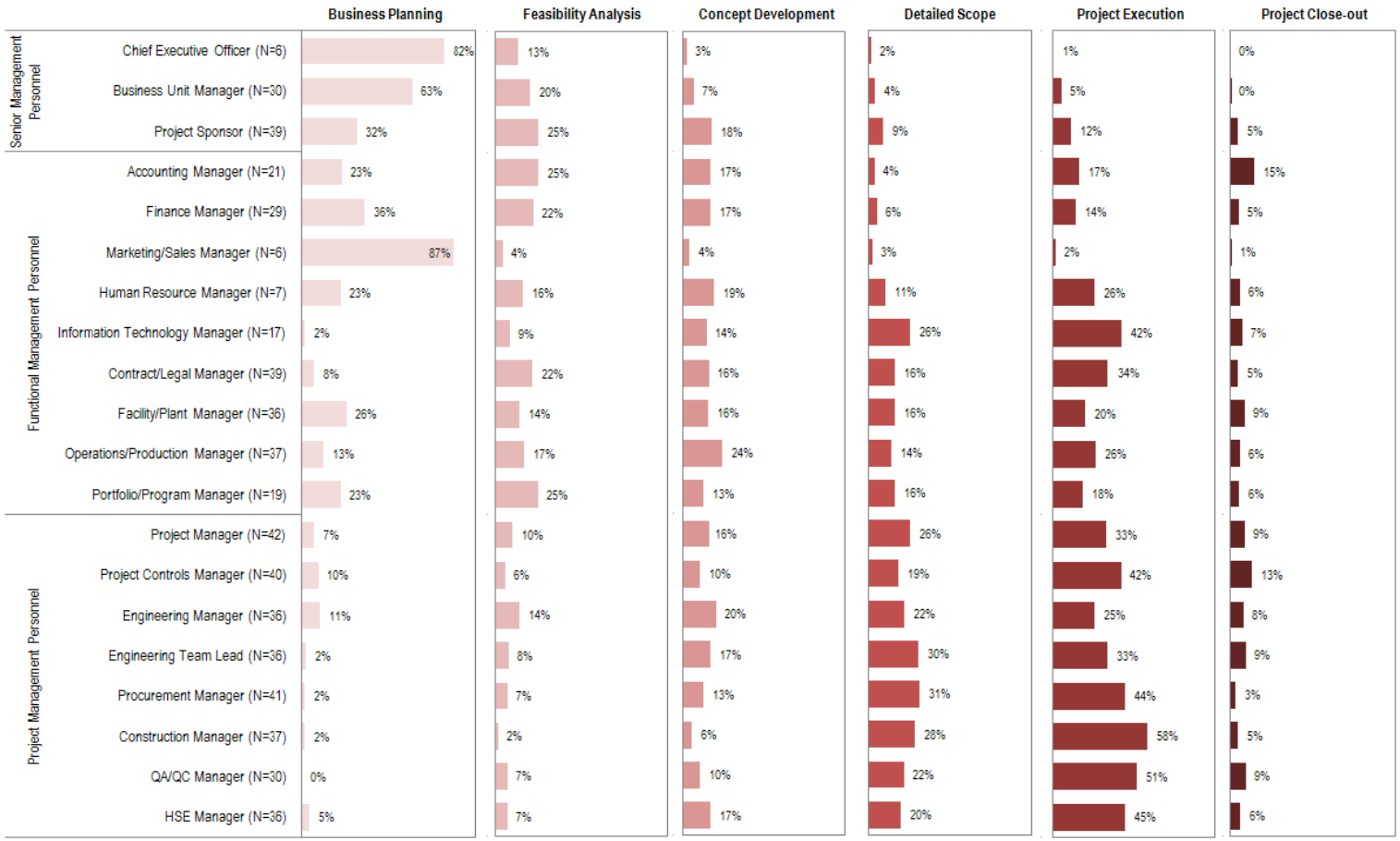


Figure 4.2 Phase Level Time Distribution of Management Personnel

4.1.3 Task Level Involvement

This section presents findings for task level involvement of management personnel. Task level involvement is important in that it can show interfaces between the business and project unit. The information on task level involvement for management personnel was collected in a separate, supplemental survey to the CII Benchmarking project questionnaire because the information is detailed and not typically captured by the system. Thus, this research collected the task level involvement of management personnel through the personnel work function relationship matrix at the company or organization level, and not at the project level. Among the nine companies which participated in the survey of this research, five companies responded to the personnel-work function relationship matrix inquiry.

Figure 4.3 summarizes task level involvement reported by management personnel. This includes all activities for the development of a capital project such as meetings, conference calls, e-mail, documentation, and review and approval of requests. Task level involvement is categorized into two types: common and uncommon, according to the response rate. The threshold to determine the category of task level involvement is 50%. The cells marked dark blue indicate basic task level involvement which describes more than half of the respondents. The cells marked light blue indicate advanced task level involvement and were indicated by less than half of the respondents. The task level involvement measure was used to validate the analysis results of relationships between personnel involvement and task interaction.

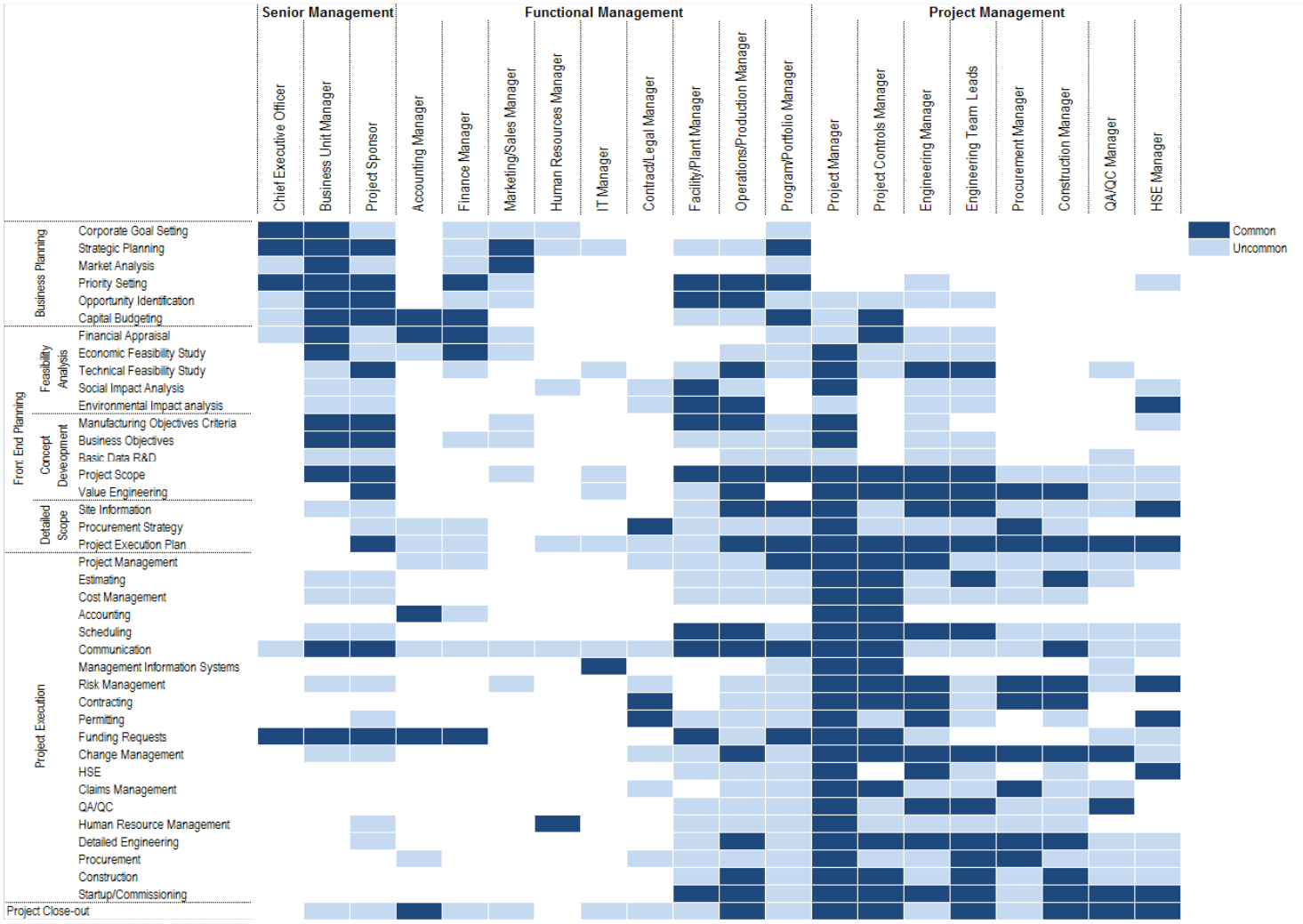


Figure 4.3 Task Level Participations of Management Personnel

4.2 BUSINESS-PROJECT INTERACTION

This section explores the interactions reported at the interfaces between business and project units during the development of a capital project. Kerzner (1992) and Stuckenbruck (1998) addressed the project-top management interfaces and project-functional management interfaces and they pointed out that the well interaction and collaboration between business and project unit on these interfaces is significant in order to avoid negative impact due to misalignment between them. Thus, the following the second research proposition of the first research question can be addressed:

Proposition 1-2: The owner's business and project unit interact with each other throughout work functions of a capital project

For test this research proposition, this research investigated 40 planning and execution tasks selected based on the conceptual framework. These work functions were selected because they likely involved business and project unit interaction. This section evaluates three levels of interaction: task level interaction, phase level interaction, and project level interaction. Task level interaction indicates whether the business and project unit worked together in a given work function, or not, and to what degree. Phase and project level interaction are calculated by aggregating task level interaction presented using descriptive statistics on the level of interaction at the phase and project level.

4.2.1 Task Level Interaction

4.2.1.1 Task level Collaboration

Task collaboration is investigated first to determine if interaction between the business and project unit occurred. In following sections, the level of interaction will be examined. Among the 42 responses, task collaborations for planning tasks are summarized in Figure 4.4.

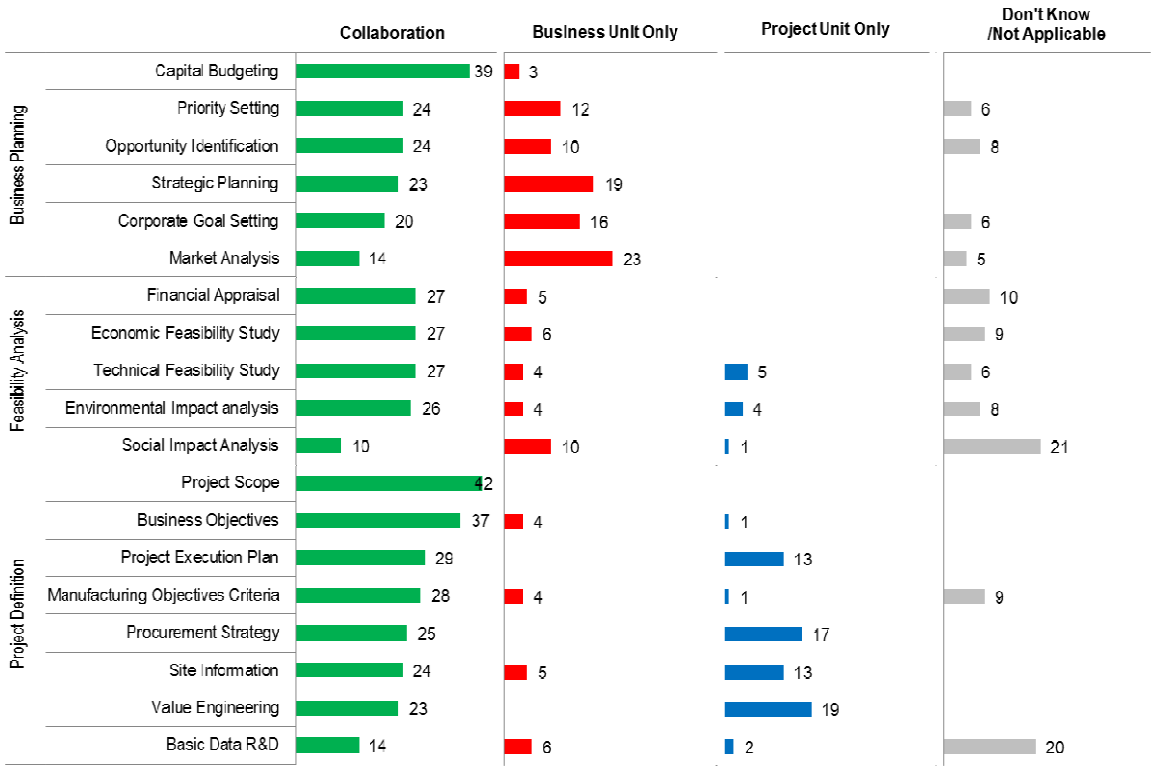


Figure 4.4 Task Level Collaborations in Planning

In business planning, capital budgeting is a task in which the business and project units reported that they worked together most frequently, at 93%, followed by priority

setting (57%) and opportunity identification/preliminary screening (57%), and strategic planning (55%). Corporate goal setting and market analysis received less frequent collaboration, compared to other tasks. In addition, opportunity identification/preliminary screening reported relatively high responses of “No Response” at 19% of 42 projects in the study.

During the feasibility analysis phase, 64% of the projects reported that the business and project units worked together on financial appraisal, economic feasibility, and technology feasibility, with 62% collaborating on environmental impact analysis. In contrast, 50% indicated “No Response” on social impact analysis. Social impact analysis had the least collaboration compared to other tasks during feasibility analysis.

The major activity during concept development and detailed scoping is project definition which includes obtaining the basis for the project design, engineering, and execution approach. Every project reported, business and project unit collaboration on project scope (100%), followed by business objectives (88%), manufacturing objectives criteria (67%), and value engineering (55%). Among the tasks during concept development, collaboration occurred on basic data R&D only 33% of the time, with 48% responding “Don’t Know or Not Applicable.” In detailed scope, business and project unit most frequently collaborated with each other on developing the project execution plan, (69%), followed by procurement strategy, (60%), and site information, (57%).

As can be seen in Figure 4.5, among execution tasks, the project unit collaborated with the business unit on developing the funding request in 98% of responses, followed by communications (90%), health/safety/environment (90%), change management (79%),

scheduling (69%), and risk management (69%). Interestingly, a total of 31% of the projects provided "No Response" regarding claims management or human resource management.

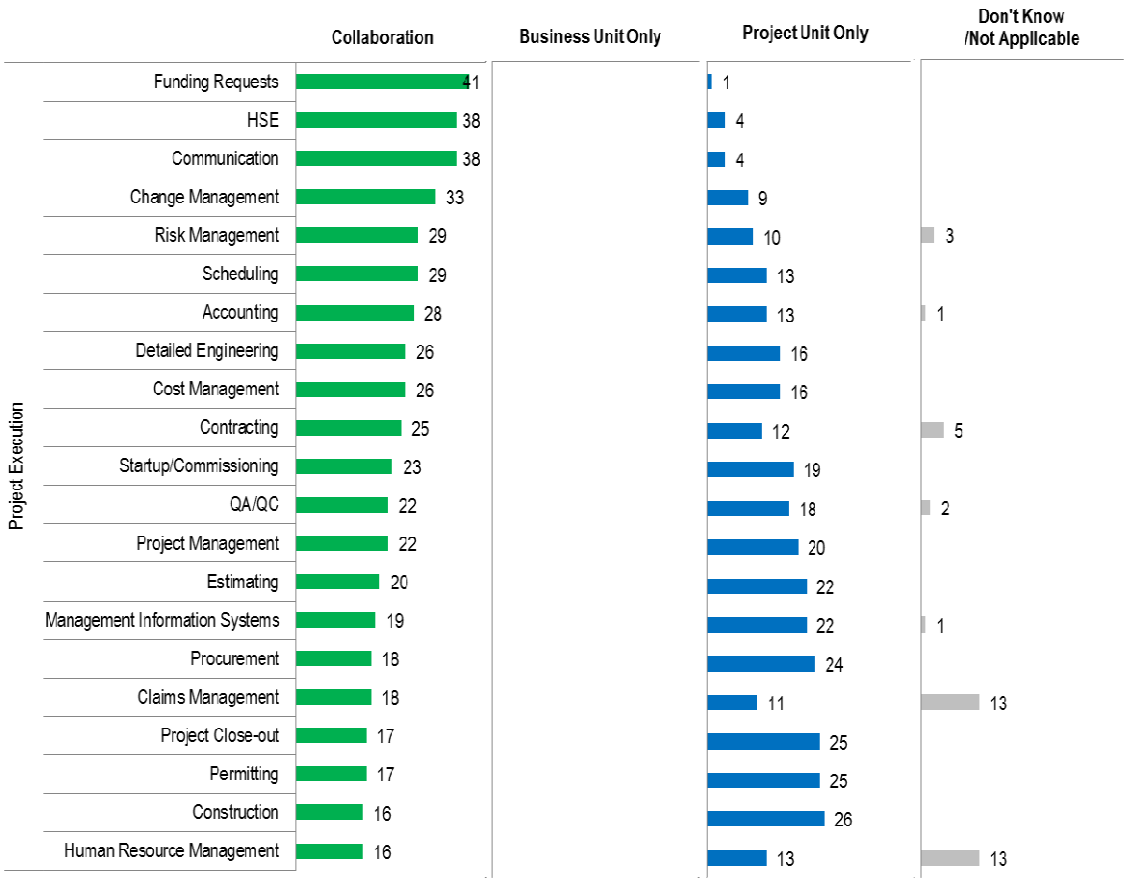


Figure 4.5 Task Level Collaborations in Execution

During execution, collaboration was found mostly on controls-related tasks such as HSE, risk management, scheduling, cost management, and QA/QC. Additionally, collaboration occurred on funding-related tasks such as funding requests, change management, and accounting. On the other hand, collaboration occurred less frequently on tasks such as procurement, construction, and project close-out.

4.2.1.2 Task Level Interaction

This section presents the level of task interaction between the business and project units and builds on data presented in the previous section that identified the existence of management interfaces. The responses for task level interaction are summarized and detailed in Table 4.4. The table presents both the count for each response as well as the mean and standard deviation for the responses in each task level interaction. The mean value is calculated by averaging the respondent's answers as translated into interval values, excluding "don't know" or "not applicable."

There seems to be wide variations in task level interaction. As can be seen in Table 4.5, the responses did not tend to be normally distributed. If there is no task level collaboration between a business and a project unit, the response of is "No Interaction (NI)." When projects reported that collaboration occurred on a given task, the distribution of the responses tended to be skewed toward higher levels. This tendency shows why the standard deviation tends to have values greater than 1 for most task level interaction. In addition, some tasks such as social impact analysis, basic data R&D, and human resources management had many more responses of Not Applicable compared to others. This indicates that those tasks were not usually applied.

Table 4.4 Descriptive Statistics: Respondent's Answers of Task Interaction

Phase	Work Function	Respondent's Answers									Descriptive Statistics			
			Level of Interaction								Mean			St. Dev.
			0	1	2	3	4	5						
		N	NI	VP	P	M	G	VG	NA	DK	N*	Value	Rank	
Business Planning	Corporate Goal Setting	42	16	6		2	9	3		6	36	1.750	29	1.948
	Strategic Planning	42	19	6		11	4	2			42	1.548	31	1.699
	Market Analysis	42	23	3		9	2		5		37	1.027	40	1.462
	Priority Setting	42	12		3	5	11	5		6	36	2.500	17	1.949
	Opportunity Identification	42	10	6	1	5	5	7	1	7	34	2.294	23	1.993
	Capital Budgeting	42	3			13	10	10		6	36	3.583	4	1.360
Front End Planning	Financial Appraisal	42	5		6	7	14		4	6	32	2.781	12	1.431
	Economic Feasibility Study	42	6		1	3	19	3	3	6	33	3.091	8	1.721
	Technical Feasibility Study	42	9		1	7	12	7		6	36	2.944	10	1.866
	Social Impact Analysis	42	11		6	2	2		15	6	21	1.238	38	1.446
	Environmental Impact Analysis	42	8	1	6	2	13	4	2	6	34	2.676	13	1.804
	Manufacturing Objectives Criteria	42	5			12	13	3	3	6	33	3.121	7	1.474
	Business Objectives	42	5			12	10	9		6	36	3.361	5	1.570
	Basic Data R&D	42	8	6	4	2		2	14	6	22	1.364	36	1.529
	Project Scope	42		1		9	7	19		6	36	4.194	2	1.009
	Value Engineering	42	19			14	3	6		6	36	2.333	21	1.912
	Site Information	42	18		6	4	3	11		6	36	2.528	16	2.091
	Procurement Strategy	42	17		1	4	8	12		6	36	2.944	10	2.110
	Project Execution Plan	42	13		2	2	9	10		6	36	2.667	14	2.165

- NI: No Interaction, VP: Very Poor Interaction, P: Poor Interaction, M: Moderate Interaction, G: Good Interaction, VG: Very Good Interaction
- N* indicates effective responses to calculate mean excluding "Not Applicable (NA)" and "Don't Know (DK)"

Table 4.4 Descriptive Statistics: Respondent's Answers of Task Interaction (Continued)

Phase	Work Function	Respondent's Answers								Descriptive Statistics			
			Level of Interaction										
			0	1	2	3	4	5			Mean		St.
		N	NI	VP	P	M	G	VG	NA	DK	N*	Value	Rank	Dev.
Project Execution	Project Management	42	20			9	8	5			42	2.000	26	2.012
	Estimating	42	22		1	8	5	6			42	1.810	28	2.027
	Cost Management	42	16			7	8	5		6	36	2.167	24	2.049
	Accounting	42	13		1	9	5	7	1	6	35	2.400	18	2.018
	Scheduling	42	13		2	13	5	4		6	36	2.306	22	1.802
	Communication	42	4			13	10	8		6	36	3.306	6	1.546
	Management Information Systems	42	22		3	13	1	2	1		41	1.439	33	1.659
	Risk Management	42	10		4	12	5	8	3		39	2.667	14	1.826
	Contracting	42	12			8	5	6		11	31	2.387	19	2.044
	Permitting	42	25			8	6	3			42	1.500	32	1.903
	Funding Requests	42	1			2	11	22		6	36	4.444	1	0.969
	Change Management	42	9		3	5	7	12		6	36	3.028	9	1.993
	HSE	42	4		2	5	14	11		6	36	3.611	3	1.536
	Claims Management	42	11	6		4	6	2	6	6	30	1.733	30	1.837
	QA/QC	42	18			3	9	10	2		40	2.375	20	2.238
	Human Resource Management	42	13	6	3	4	2	1	12	1	29	1.276	37	1.509
	Detailed Engineering	42	16		7	3	6	4		6	36	1.861	27	1.900
	Procurement	42	24		7	1	8	2			42	1.405	35	1.795
	Construction	42	26		6	6		4			42	1.190	39	1.700
	Startup/Commissioning	42	19		4	4	4	11			42	2.167	24	2.174
	Project Close-out	42	25	1		7	7	2			42	1.429	34	1.850

- NI: No Interaction, VP: Very Poor Interaction, P: Poor Interaction, M: Moderate Interaction, G: Good Interaction, VG: Very Good Interaction
- N* indicates effective responses to calculate mean excluding "Not Applicable (NA)" and "Don't Know (DK)"

Table 4.5 presents task level interaction by cost category. Among the planning tasks, two task level interactions, strategic planning and market analysis, were positively correlated with project size. That is, business and project units interacted with each other more on those tasks in large projects. On the other hand, task level interaction were excluded in small projects costing less than $5MM due to small samples less than 10.

Table 4.5 Descriptive Statistics: Task Level Interaction by Cost Category

Phase		Work Functions	All			$5MM-$50MM			> $50MM		
			N	Mean	S.D.	N	Mean	S.D	N	Mean	S.D
Business Planning		Corporate Goal Setting	36	1.750	1.948	17	1.765	2.016	14	1.357	1.946
		Strategic Planning**	42	1.548	1.699	17	1.765	1.821	14	2.500	1.401
		Market Analysis*	37	1.027	1.462	13	1.846	1.676	13	1.077	1.382
		Priority Setting	36	2.500	1.949	17	2.235	2.047	14	2.357	1.692
		Opportunity Identification	34	2.294	1.993	17	2.294	1.961	12	1.333	1.670
		Capital Budgeting	36	3.583	1.360	17	3.471	1.505	14	3.643	1.393
Front End Planning	Feasibility Analysis	Financial Appraisal	32	2.781	1.431	13	2.692	1.494	14	2.857	1.406
		Economic Feasibility Study	33	3.091	1.721	15	3.133	1.642	13	2.769	1.691
		Technical Feasibility Study	36	2.944	1.866	17	3.059	1.853	14	2.500	1.787
		Social Impact Analysis	21	1.238	1.446	8	1.000	1.069	9	0.444	0.882
		Environmental Impact analysis	34	2.676	1.804	16	2.563	1.672	13	2.385	1.805
	Concept Development	Manufacturing Objectives Criteria	33	3.121	1.474	15	3.467	1.187	13	2.846	1.725
		Business Objectives	36	3.361	1.570	17	4.000	0.866	14	2.786	1.968
		Basic Data R&D	22	1.364	1.529	7	1.000	1.000	10	1.400	2.011
		Project Scope	36	4.194	1.009	17	4.294	0.849	14	4.143	0.949
		Value Engineering	36	2.333	1.912	17	3.353	1.539	14	1.929	1.817
	Detailed Scope	Site Information	36	2.528	2.091	17	3.353	1.766	14	2.429	2.138
		Procurement Strategy	36	2.944	2.110	17	3.176	1.944	14	2.357	2.274
		Project Execution Plan	36	2.667	2.165	17	3.471	1.772	14	2.643	2.274

** indicates *p*-value of the Somers' *d* coefficient is lower than 0.05. * indicates *p*-value is lower than 0.1

Table 4.5 Descriptive Statistics: Task Level Interaction by Cost Category (Continued)

Phase	Work Functions	All			$5MM-$50MM			> $50MM		
		N	Mean	St. Dev.	N	Mean	St. Dev.	N	Mean	St. Dev.
Project Execution	Project Management**	42	2.000	2.012	17	2.882	1.764	14	2.500	2.066
	Estimating**	42	1.810	2.027	17	2.765	1.985	14	2.071	2.018
	Cost Management	36	2.167	2.049	17	3.000	1.871	14	1.929	2.056
	Accounting	35	2.400	2.018	16	2.563	1.931	14	1.714	1.899
	Scheduling	36	2.306	1.802	17	2.353	1.902	14	1.857	1.875
	Communication	36	3.306	1.546	17	3.765	1.300	14	2.929	1.730
	Management Information Systems	41	1.439	1.659	16	1.813	1.721	14	1.500	1.871
	Risk Management**	39	2.667	1.826	14	3.429	1.697	14	3.357	1.336
	Contracting	31	2.387	2.044	16	2.188	2.105	10	2.500	2.273
	Permitting**	42	1.500	1.903	17	1.706	1.929	14	2.429	1.989
	Funding Requests	36	4.444	0.969	17	4.765	0.437	14	4.000	1.359
	Change Management	36	3.028	1.993	17	3.941	1.638	14	2.357	2.205
	HSE	36	3.611	1.536	17	3.471	1.546	14	3.714	1.383
	Claims Management	30	1.733	1.837	12	1.750	1.960	13	1.308	1.750
	QA/QC	40	2.375	2.238	15	3.400	2.165	14	2.143	2.282
	Human Resource Management*	29	1.276	1.509	8	1.000	1.309	10	2.000	1.826
	Detailed Engineering	36	1.861	1.900	17	2.647	1.801	14	1.571	1.869
	Procurement**	42	1.405	1.795	17	1.706	1.863	14	1.929	1.940
	Construction**	42	1.190	1.700	17	1.588	1.770	14	1.643	1.906
	Startup/Commissioning**	42	2.167	2.174	17	3.118	2.058	14	2.714	2.054
Project Close-out		42	1.429	1.850	17	2.235	2.016	14	1.357	1.781

** indicates *p*-value of the Somers' *d* coefficient is lower than 0.05. * indicates *p*-value is lower than 0.1

During execution, some tasks were positively correlated with project size including project management, estimating, risk management, permitting, procurement, construction, and startup/commissioning.

4.2.2 Phase Level Interaction

Similar to the task level interaction assessment presented in the previous section, the phase level interactions were calculated and are shown below. Based on the 0 to 5 scale, the level of interaction was calculated by averaging the task level interactions assessed in each phase. The 5 phase indices were calculated and one overall index was calculated for the project level, consolidating all task level interaction across all phases that were surveyed. In order to construct a 0 to 10 score for each phase level interaction, the equation incorporated a factor of 2, to elevate a selection of "5" in the questionnaire to the interaction level of "10." The equation is shown below:

$$\text{Phase Level Interaction} = 2 \times \frac{\sum_{i=1}^{N} L_i}{N}$$

where L_i = Level of Interaction, and N_i = Number of Task Level Interaction Assessed

Table 4.6 presents descriptive statistics for phase level interactions. The project level and phase level interactions range from 0, indicating virtually no interaction, to 10, indicating continuous and voluntary collaboration between the business and project units.

Table 4.6 Descriptive Statistics: Phase Level Interaction

Phase		Overall (N=36)		$5MM-$50MM (N=17)		> $50MM (N=14)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Business Planning		4.405	2.365	4.467	2.690	4.117	2.334
Front End Planning	Feasibility Analysis	5.403	2.890	5.641	3.079	4.614	2.162
	Concept Development	6.142	2.403	7.235	1.965	5.379	2.419
	Detailed Scope	5.426	3.589	6.667	3.206	4.950	3.990
Project Execution		4.769	2.312	5.415	2.037	4.490	2.720
Project Close-out		3.333	3.795	4.471	4.033	2.714	3.561

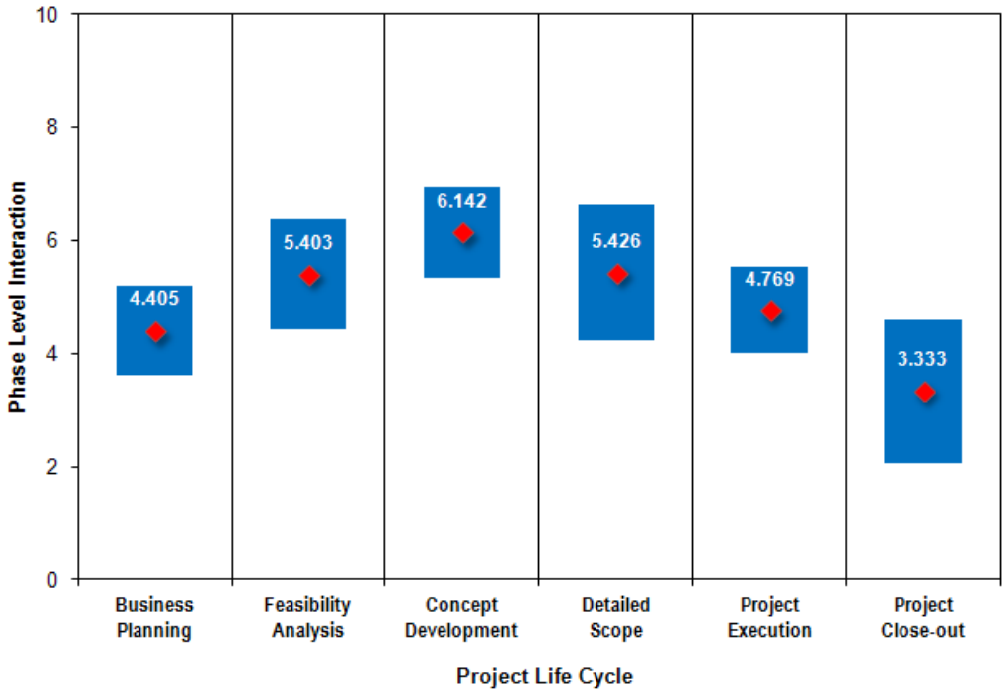


Figure 4.6 Phase Level Interaction

Figure 4.6 presents the mean and 95% confidence interval for phase level interaction. In Figure 4.6, the red diamonds indicate the average level of interaction in each phase. The blue rectangles around the red diamonds show the upper and lower 95 percent confidence limits of the means; this is to say that the height of the blue rectangles represents about four times the standard error of mean (SEM).The 95 percent confidence intervals are constructed so that they would be expected to contain the average level of interaction for the phase. The phase level interaction during the concept development phase was the highest, compared to other tasks. The findings from the phase level interaction analysis indicates that phase level interaction between the business and project unit increases starting from business planning through concept development, then decreases from concept development to project execution.

4.2.3 Project Level Interaction

Project level interaction was also calculated based on the equation for calculating phase level interaction using a given task level interaction. As can be seen in Table 4.7, the average project level interaction is 4.861 on a 0 to 10 scale. The project level interaction in the cost category of $5MM - $50MM was found to be slightly higher than those in the > $50MM cost category.

Table 4.7 Descriptive Statistics: Project Level Interaction

	Overall (N=36)		$5MM-$50MM (N=17)		> $50MM (N=14)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Project Level Interaction	4.861	1.982	5.296	1.849	4.596	2.220

St. Dev.: Standard Deviation

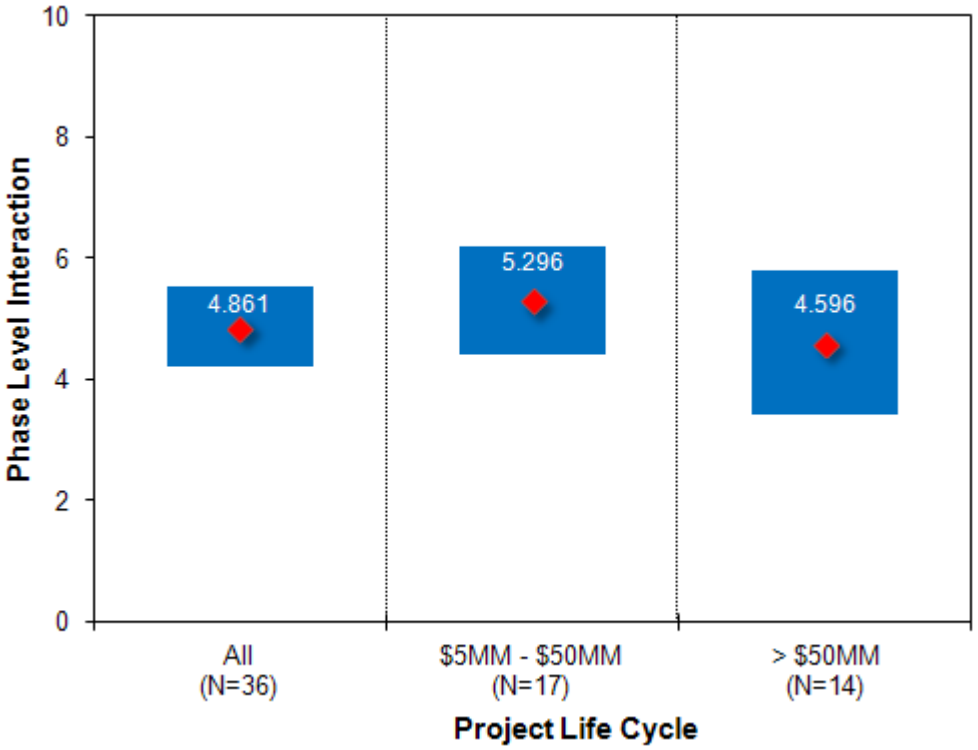


Figure 4.7 Project Level Interaction by Cost Category

4.3 RELATIONSHIP BETWEEN INVOLVEMENT AND INTERACTION

Although the involvement of management personnel in a project is a prerequisite to interaction between business and project units, it has not been recognized by construction research. This section addresses the third research proposition of the first research question as follow:

> *Proposition 1-3: The more the business unit personnel interface with a capital project, the more the business and project unit interact with each other in the work functions which business unit personnel are involved in.*

Given the personnel involvement (PI) and task interaction (TI) assessed in the previous section, the relationships are examined below. First, the hypothetical relationships between personnel involvement and task interaction are developed. The relationships are then validated based on the task level involvement of management personnel collected through inquiry via the personnel-work function matrix. The validated relationships were then analyzed through ordinal measure of association using Somers' *d* correlation coefficient.

4.3.1 Data Preparation

Due to the lack of existing knowledge about the relationship between PI and TI, this research hypothetically developed relationships for personnel involvement and task interaction based on the conceptual framework for identifying the business-project

interface. Figure 4.8 describes the identification process for PI and TI. Based on the conceptual framework, 20 management personnel and 40 work functions were included for the investigation. From the framework, 800 hypothetical combinations of the relationships were developed, based on the possible relationships between personnel involvement and work functions. Management personnel were not necessarily involved in all work functions for the development of a capital project, however. Therefore, an additional survey was conducted to collect company-based information about the personnel-work function relationship matrix. After validation, a total of 499 relationships between PI and TI were identified. Those validated relationships between PI and TI are presented in Appendix C as task level involvement.

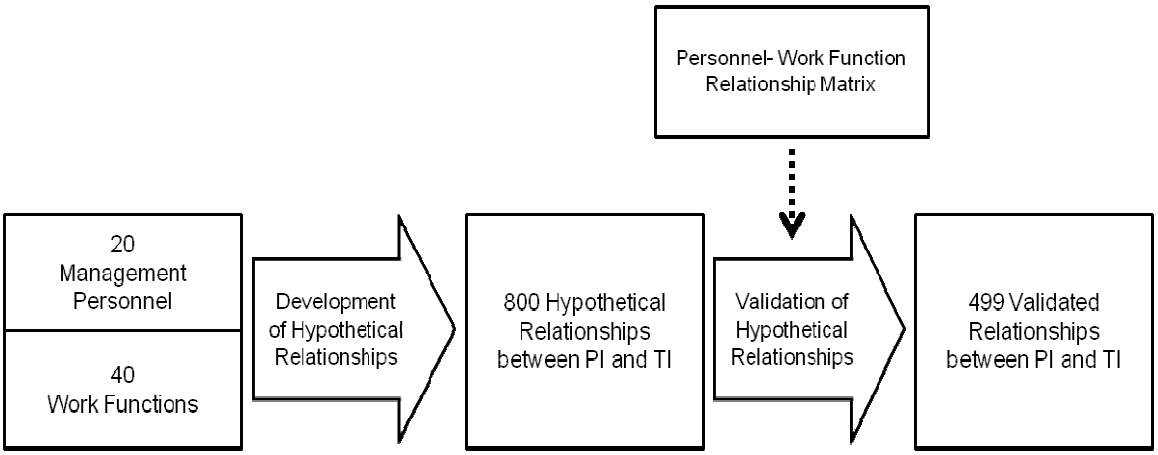


Figure 4.8 Identification Process for Relationships between PI-TI

4.3.2 Simple Correlation

This section examines the relationships between PI and TI. The Somers' *d* correlation coefficient was used to measure the association between PI and TI. The PI

was measured with four ordinal categories of total work-hours and the TI was measured with six ordinal categories from the level of interaction. Therefore, a relationship set between PI and TI is a 4×6 asymmetric contingency table.

The Somers' *d* coefficient is a nonparametric measure of correlation for ordinal or ranked variables that task ties into account (de Vaus, 2002). The sign of the coefficient indicates the direction of the relationship, and its absolute value indicates the strength, with larger absolute values indicating stronger relationships. Possible values range from -1 to 1, but a value of -1 or +1 can be obtained only from square tables, (Agresti, 2013). To obtain accurate and reliable results for the test of significance, this research also adopted the method which can be applied to small samples of less than 30 (Mehta and Patel, 2011).

The descriptive statistics presented in the previous section confirm that the actual work-hours of most management personnel are significantly correlated with project size. Therefore, simple correlations for three cost categories are provided in Appendix C. This section provides the summary of the results in Table 4.8. Any results that did not meet CII's rules for protecting member confidentiality were excluded. If the sample size used for an analysis was fewer than 10 projects or those data were from fewer than three organizations, the results were marked with the code "C.T. (confidentiality test)" and no statistical summary was provided (CII 2007). As a result, the cost category of < $5 MM was not provided. The relationships between PI and TI were validated based on the task level involvement of management personnel, as collected through the personnel-work function relationship matrix.

4.3.3 Analysis Results

The results of the Somers' *d* test at a 0.1 significance level can be seen in Appendix C. Table 4.8 summarizes the significant relationships between personnel involvement and task interaction.

Table 4.8 Significant Relationships between PI and TI

Management Personnel		All	Cost Category	
			$5MM ~ $50MM	> $50MM
	Business Unit Manager	• Opportunity Identification** • Business Objectives** • Basic Data R&D** • Site Information** • Procurement Strategy* • Project Execution Plan** • Scheduling* • Communication** • Risk Management* • Permitting** • Funding Requests* • Change Management* • Project Close-out**	• Communication**	• Basic Data R&D** • Site Information** • Estimating** • Cost Management* • Scheduling** • Risk Management* • Permitting** • Project Close-out**
	Project Sponsor		• Funding Requests*	• Human Resource Mgmt*
Functional Management Personnel	Accounting Manager	• Funding Requests**	• Funding Requests*	
	Finance Manager		• Funding Requests*	
	Facility/Plant Manager	• Funding Requests** • HSE**	• Funding Requests**	• Communication** • Funding Requests* • HSE** • Startup/Commissioning**
	Contract/Legal Manager	• Risk Management** Project Close-out**		• Risk Management*
	Operations/Production Manager	• Strategic Planning** • Market Analysis** • Capital Budgeting* • Risk Management* • QA/QC* • Human Resource Mgmt* • Procurement* • Startup/Commissioning*	• Strategic Planning** • Capital Budgeting** • Economic Feasibility Study** • Human Resource Mgmt**	• Priority Setting* • Capital Budgeting* • Funding Requests* • Change Management**
	Portfolio/Program Manager			• Human Resource Mgmt**

Table 4.8 Significant Relationships between PI and TI (Continued)

Management Personnel		All	Cost Category	
			$5MM ~ $50MM	> $50MM
Project Management Personnel	Project Manager	• Value Engineering** • Site Information** • Project Execution Plan** • Project Management** • Estimating** • Cost Management* • Risk Management** • Permitting** • Change Management* • Detailed Engineering* • Construction** • Startup/Commissioning** • Project Close-out*		
	Project Controls Manager	• Risk Management*	• Risk Management** • Human Resource Mgmt**	
	Engineering Manager		• Funding Requests**	
	Engineering Team Leads	• Risk Management**	• Risk Management** • Human Resource Mgmt**	
	Construction Manager	• Estimating** • Risk Management** • Contracting* • Permitting** • Procurement** • Construction** • Startup/Commissioning** • Project Close-out**	• Risk Management** • Contracting** • Permitting** • Claims Management** • Human Resource Mgmt** • Procurement** • Project Close-out**	
	QA/QC Manager	• MIS** • Risk Management**	• MIS** • Risk Management* • QA/QC*	
	HSE Manager	• Priority Setting** • Risk Management** • Startup/Commissioning*	• Priority Setting** • Risk Management**	• Priority Setting* • Social Impact Analysis*

** indicates exact *p*-value of Somers' *d* coefficient is less than 0.05. * indicates exact *p*-value is less than 0.1

Among senior management personnel, the involvement of the business unit manager was significantly correlated with task interaction during planning and execution including opportunity identification, business objectives, basic data R&D, site information, procurement strategy, project execution plan, scheduling, communication, risk management, permitting, funding requests, change management, and project close-out. Particularly in project costing greater than $50MM, the involvement of the business unit manager was significantly correlated with basic data R&D, site information, estimating, cost management, scheduling, risk management, permitting, and project

close-out. Meanwhile, the involvement of the chief executive officer was significantly correlated with task interaction for capital budgeting. The project sponsor's involvement was significantly correlated with funding requests in projects costing $5MM-$50MM, and with human resource management in projects costing > $50MM.

Among functional management personnel, an interesting finding from the relationships between PI and TI was that the marketing manager's involvement was found to have a significantly association with task interaction in early planning work functions such as priority setting, opportunity identification, economic feasibility analysis, and project scope. Another interesting finding was the involvement of operations and maintenance personnel who were found to be significantly correlated with task interaction on execution work functions, as well as planning work functions. The involvement of the operations/production manager was significantly correlated with task interaction of both planning and execution work functions including strategic planning, market analysis, capital budgeting, risk management, QA/QC, human resource management, procurement, and startup/commissioning. The involvement of the facility/plant manager was significantly correlated with funding requests in all cost categories. In projects costing >$50MM in particular, involvement was found to be significantly correlated on communication, HSE, and startup/commissioning tasks. The involvement of the contract/legal manager was significantly correlated with task interaction of risk management and project close-out. Particularly in projects costing greater than $50MM, risk management was significantly correlated with the contract/legal mangers' involvement.

4.4 DISCUSSIONS

This section summarizes the descriptive statistics captured in the course of documenting current states of the business-project interface. Figure 4.9 illustrates the project-level involvement of business and project unit personnel by total work-hours. Among 42 projects, 56.7% of business unit personnel are involved in a capital project. Among them, most business unit personnel spent between 1-400 hours on the surveyed capital project (52.4%). Considering the average project duration, 130 weeks, this result indicates that the business unit personnel interface with a capital project for less than 10% of the average project duration.

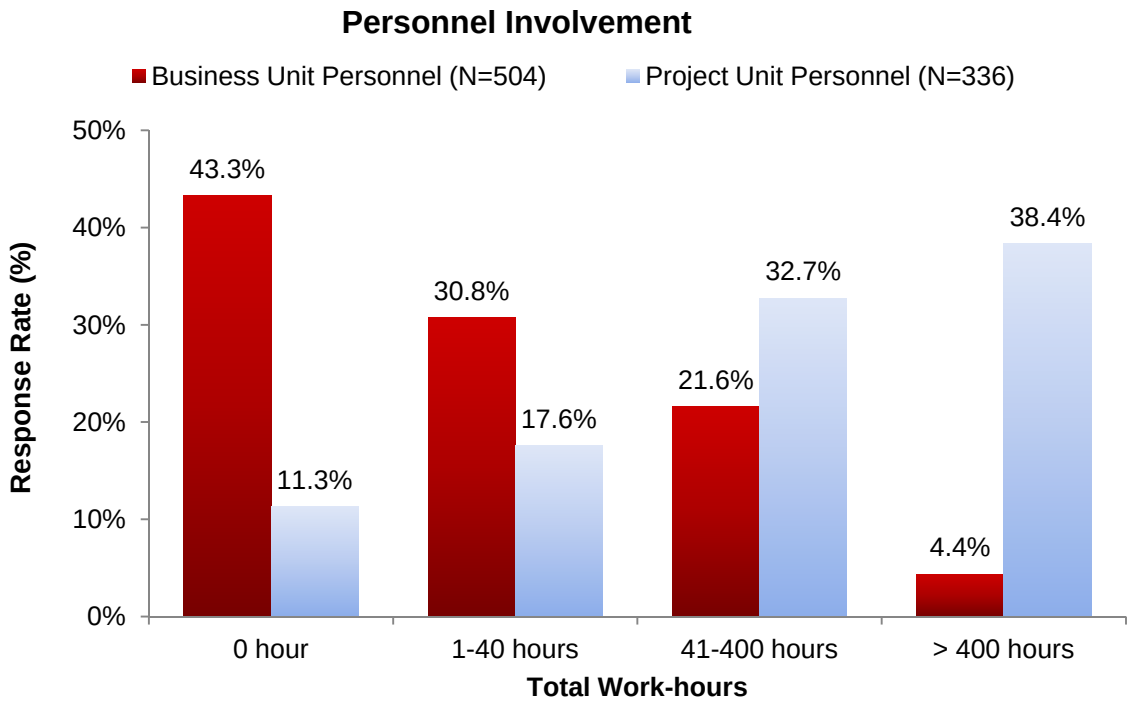


Figure 4.9 Personnel Involvement

Table 4.9 presents the categorization of management personnel by response rate in detail. Among the business unit personnel, the project sponsor, contract/legal manager, operations/production manager, and facility/plant manager were found to be involved in a capital project more than 75% of the time, across all cost categories.

Table 4.9 Percent Phase Participation of Management Personnel

Percent of Responses	All (N=42)	< $5MM (N=11)	$5MM - $50MM (N=17)	> $50MM (N=14)
> 75%	• Project Manager • Procurement Manager • Project Controls Manager • **Project Sponsor** • **Contract/Legal Manager** • **Operations/Production Manager** • Construction Manager • **Facility/Plant Manager** • Engineering Manager • Engineering Team Lead • HSE Manager	• Project Manager • Procurement Manager • **Operations/Production Manager** • **Facility/Plant Manager** • Construction Manager • Engineering Manager • **Portfolio/Program Manager** • **Contract/Legal Manager** • Engineering Manager • Project Controls Manager	• Project Manager • Project Controls Manager • **Project Sponsor** • Procurement Manager • **Contract/Legal Manager** • HSE Manager • **Business Unit Manager** • **Operations/Production Manager** • Engineering Manager • **Facility/Plant Manager**	• Project Manager • Project Controls Manager • **Project Sponsor** • Construction Manager • Procurement Manager • HSE Manager • Engineering Manager • Engineering Team Lead • **Contract/Legal Manager** • **Operations/Production Manager** • QA/QC Manager • **Facility/Plant Manager**
50% ~ 75%	• **Business Unit Manager** • QA/QC Manager • **Finance Manager**	• **Project Sponsor** • HSE Manager • **Finance Manager** • **Business Unit Manager**	• Construction Manager • Engineering Team Lead • **Finance Manager** • **Accounting Manager**	• **Finance Manager** • **Business Unit Manager** • **Information Technology Manager**
25% ~ 50%	• **Accounting Manager** • **Portfolio/Program Manager** • **Information Technology Manager**	• QA/QC Manager • **Marketing/Sales Manager** • **Accounting Manager**	• **Information Technology Manager**	• **Accounting Manager** • **Human Resource Manager** • **Portfolio/Program Manager**
< 25%	• **Human Resource Manager** • **Chief Executive Officer** • **Marketing/Sales Manager**	• **Information Technology Manager** • **Chief Executive Officer** • **Human Resource Manager**	• **Portfolio/Program Manager** • **Chief Executive Officer** • **Human Resource Manger** • **Marketing/Sales Manager**	• **Chief Executive Officer** • **Marketing/Sales Manager**

Table 4.10 presents the management personnel sorted by the percentage of their phase participation. Phase participation was categorized into four groups: >75%, 25% ~ 75%, and < 25%.

Table 4.10 Percent Phase Participation of Management Personnel

Phase		>75%	50% ~ 75%	25% ~ 50%
Business Planning		• **Project Sponsor**	• **Business Unit Manager** • **Facility/Plant Manager** • Project Manager • Engineering Manager	• **Accounting Manager** • **Finance Manager** • **Operations/Production Manager** • **Portfolio/Program Manager** • Project Controls Manager • HSE Manager
Front End Planning	Feasibility Analysis	• **Project Sponsor** • **Facility/Plant Manager** • Project Manager • Engineering Manager	• **Contract/Legal Manager** • **Operations/Production Manager** • Engineering Team Lead	• **Business Unit Manager** • **Accounting Manager** • **Finance Manager** • **Information Technology Manager** • **Portfolio/Program Manager** • Project Controls Manager • Procurement Manager • QA/QC Manager • HSE Manager
	Concept Development	• **Project Sponsor** • **Facility/Plant Manager** • **Operations/Production Manager** • Project Manager • Engineering Manager • Engineering Team Lead	• **Contract/Legal Manager** • Project Controls Manager • Procurement Manager • QA/QC Manager • HSE Manager	• **Business Unit Manager** • **Accounting Manager** • **Finance Manager** • **Information Technology Manager** • **Portfolio/Program Manager** • Construction Manager
	Detailed Scope	• Project Manager • Project Controls Manager • Engineering Manager • Engineering Team Lead • Procurement Manager • Construction Manager	• **Project Sponsor** • **Facility/Plant Manager** • **Contract/Legal Manager** • **Operations/Production Manager** • QA/QC Manager • HSE Manager	• **Business Unit Manager** • **Information Technology Manager** • **Portfolio/Program Manager**
Project Execution		• **Facility/Plant Manager** • Project Manager • Project Controls Manager • Engineering Manager • Engineering Team Lead • Procurement Manager • Construction Manager • HSE Manager	• **Project Sponsor** • **Contract/Legal Manager** • **Operations/Production Manager** • QA/QC Manager	• **Business Unit Manager** • **Finance Manager** • **Information Technology Manager** • **Portfolio/Program Manager**
Project Close-out		• Project Manager • Project Controls Manager • Engineering Manager	• **Facility/Plant Manager** • Engineering Team Lead • Construction Manager • QA/QC Manager • HSE Manager	• **Project Sponsor** • **Accounting Manager** • **Finance Manager** • **Information Technology Manager** • **Contract/Legal Manager** • **Operations/Production Manager** • **Portfolio/Program Manager** • Procurement Manager

Figure 4.10 summarizes overall collaboration between the business and project unit. Business-project collaborations were found to exist in 59.8% of the 1,680 task-based collaborations recorded in the 42 projects surveyed. This result indicates that business and project units work together in about 60% of the work functions.

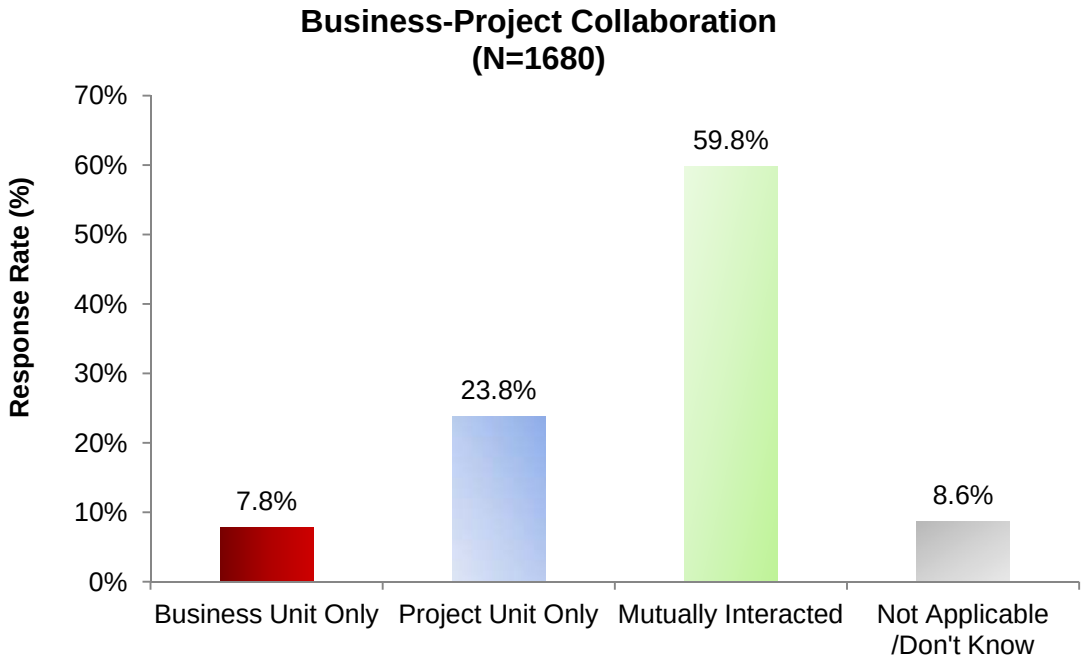


Figure 4.10 Business-Project Collaboration

Table 4.11 presents the top 10 and bottom 10 task level interactions. Funding requests received the highest level of interaction between business and project units among all work functions. Most work functions with higher levels of interaction belonged to front end planning phases such as project scope, capital budgeting, business objectives, manufacturing objectives criteria, economic feasibility study, and technical feasibility study. Likewise, work functions with lower levels of interaction were those

that required specific business or project functional knowledge, such as strategic planning and market analysis in business planning, construction, procurement, project close-out, human resource management, and management information systems in project execution.

Table 4.11 Top 10 and Bottom 10 Task Level Interactions

Rank	Top 10		Bottom 10	
	Work Functions	Mean	Work Functions	Mean
1	Funding Requests	4.444	Market Analysis	1.027
2	Project Scope	4.194	Construction	1.190
3	HSE	3.611	Social Impact Analysis	1.238
4	Capital Budgeting	3.583	Human Resource Management	1.276
5	Business Objectives	3.361	Basic Data R&D	1.364
6	Communication	3.306	Procurement	1.405
7	Manufacturing Objectives Criteria	3.121	Project Close-out	1.429
8	Economic Feasibility Study	3.091	Management Information Systems	1.439
9	Change Management	3.028	Permitting	1.500
10	Technical Feasibility Study	2.944	Strategic Planning	1.548

Table 4.12 presents a comparison of the top 10 task interactions by cost category. Most work functions with a higher level of interaction were similar in both the $5MM-$50MM and >$50MM cost categories. The distinction between them is that work functions in feasibility analysis had a higher level of interaction in projects that belonged to the >$50MM cost category, while work functions during project execution reported higher levels of interaction in projects of the $5MM-$50MM cost category.

Table 4.12 Top 10 in Task Level Interactions by Cost Category

Rank	$5MM - $50MM		> $50MM	
	Work Functions	Mean	Work Functions	Mean
1	Funding Requests	4.765	Project Scope	4.143
2	Project Scope	4.294	Funding Requests	4.000
3	Business Objectives	4.000	HSE	3.714
4	Change Management	3.941	Capital Budgeting	3.643
5	Communication	3.765	Risk Management	3.357
6	Capital Budgeting	3.471	Communication	2.929
7	Project Execution Plan	3.471	Financial Appraisal	2.857
8	HSE	3.471	Manufacturing Objectives Criteria	2.846
9	Manufacturing Objectives Criteria	3.467	Business Objectives	2.786
10	Risk Management	3.429	Economic Feasibility Study	2.769

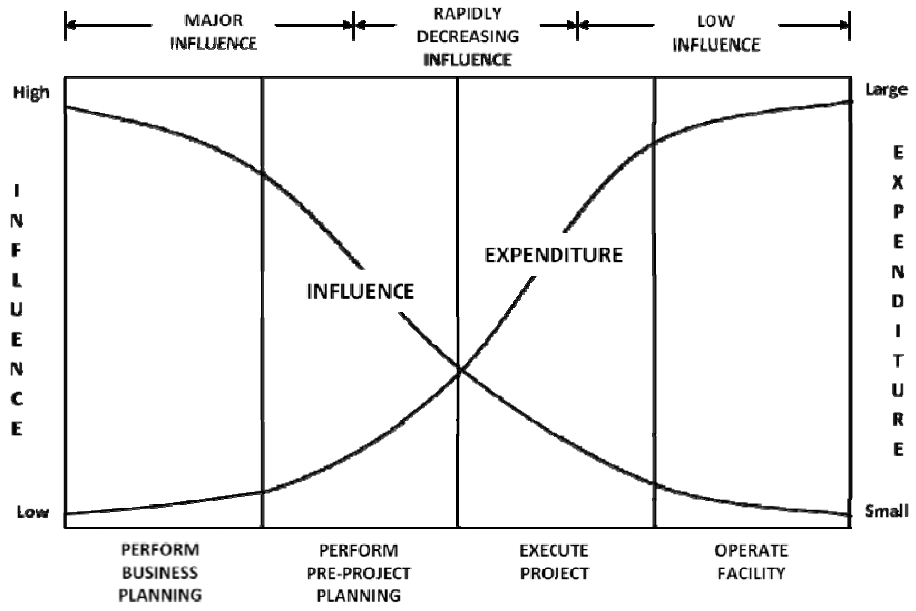


Figure 4.11 Influence and Expenditure Curve for the Project Life Cycle (CII, 1994)

From the results of the investigation into personnel involvement and task-based business-project interaction, business-project interfaces and project lifecycle are compared. Figure 4.11 demonstrates the influence and expenditure curve for the project

life cycle developed by CII Research Team 39 (1994). This diagram indicates that the early stages in the project life cycle can have a significant influence on a project's chance for success. The curve labeled "influence" reflects the ability of a company to affect the results of performance during the project life cycle. In essence, the effects of decisions made in the business planning and pre-project planning (front end planning) stages have a higher influence on the project's performance and can be accomplished with less expenditure (CII, 2006). Considering this fact, the business-project interfaces need to be well managed and coordinated during business planning and front end planning.

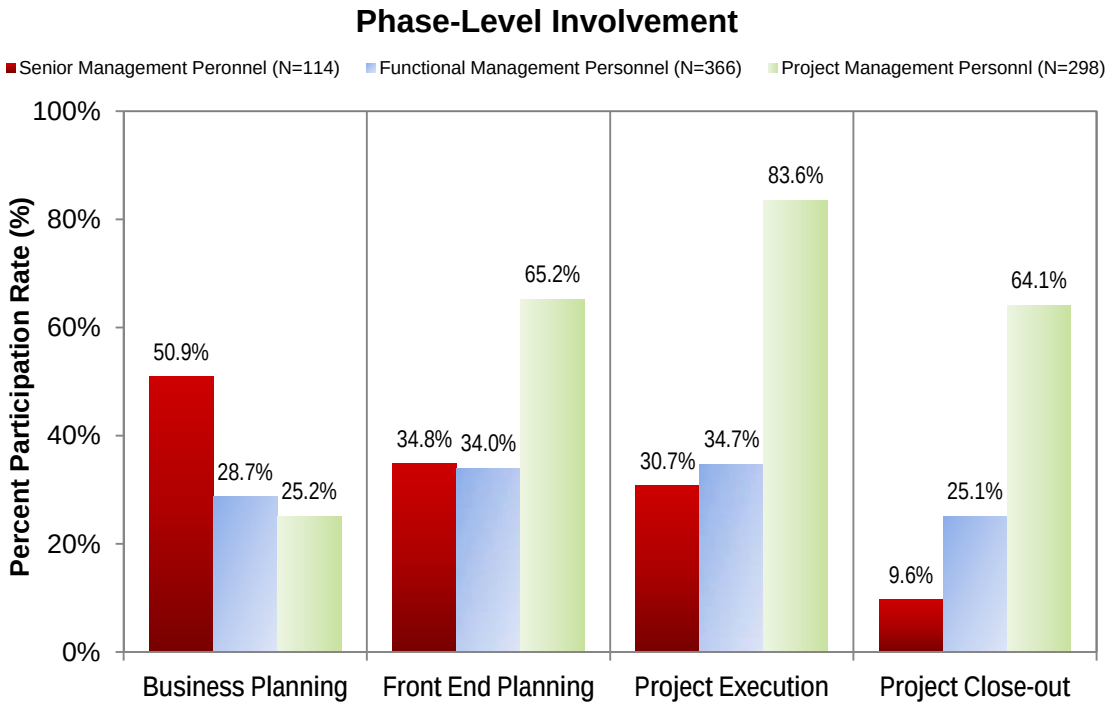


Figure 4.12 Personnel Involvement across Project Life Cycle

Figure 4.13 illustrates the phase-level involvement of management personnel throughout the project life cycle. The percent participation rate of senior management personnel peaks during business planning. Participation then drops gradually at front end planning and project execution, then rapidly as the project draws to a close. On the other hand, the rate of functional management personnel seems to remain steady across the project life cycle. Otherwise, the percent participation rate of project management personnel is similar to the typical cost and staffing levels presented in PMBoK (PMI, 2008). The PMBoK reports that the rate is low at the start, peak during project execution, and drops remarkably as the project gets to project close-out. Phase-level interaction between business and project units throughout the project life cycle is shown in Figure 4.13. The business-project interactions are low at business planning, peak during front end planning, and drop gradually as the project draws to project close-out.

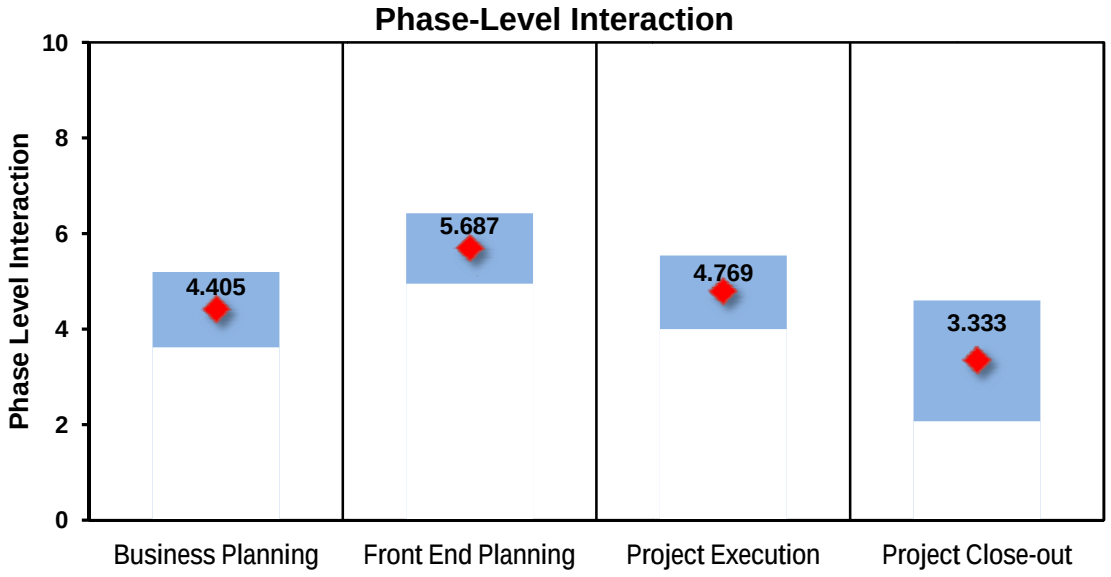


Figure 4.13 Business-Project Interaction across Project Life Cycle

Table 4.13 summarized propositions of the research question one and major findings.

Table 4.13 Summary of Propositions and Findings for Research Question One

Proposition 1-1: An owner organization involves both business and project unit personnel in the development of a capital project. **Findings:** • 56.7% of business unit personnel were involved in a capital project • Among the business unit personnel, the following personnel highly participated in a project throughout project life cycle (>50% of responses) - > 75%: Project Sponsor, Contract/Legal, Operations/Production, Facility/Plant - 50% ~ 75%: Business Unit Manager, Finance Manager • As to be expected, most project management personnel are involved in a project.
Proposition 1-2: The owner's business and project unit interact with each other throughout work functions of a capital project. **Findings:** • 59.8% of response shows that business and project unit interact with each other • The business-project interactions are low at business planning, peak at front end planning, and drop gradually as the project draws to project close-out. - Top 10 task-based interaction: project definition and funding-related tasks - Bottom 10 task-based interaction: specialized functional tasks
Proposition 1-3: The more the business unit personnel interface with a capital project, the more the business and project unit interact with each other for the work functions which the business unit personnel are involved in. **Findings:** • 449 valid relationships between management personnel and work functions • The more the business unit manager is involved in a project, the more the business and project unit interact with each other in the project definitions, funding and control tasks: • The more the accounting manager is involved in a project, the more the business and project unit interact with each other in the task of funding requests • The more the facility/plant manager is involved in a project, the more the business and project unit interact with each other in the tasks of funding requests and HSE. • The more the contract/legal manager is involved in a project, the more the business and project unit interact with each other in the tasks of risk management and project close-out • The more the operations/production manager is involved in a project, the more the business and project unit interact with each other in the tasks of strategic planning, market analysis, capital budgeting, risk management, QA/QC, human resource management, procurement, and startup/commissioning

CHAPTER 5: EFFECTS BUSINESS-PROJOECT INTERFACE ON CAPITAL PROJECT PERFORAMNCE

This chapter presents quantitative evidence of the effects of the business project interface on project performance outcomes. The chapter confirms the second research question, “Does the business project interface affect project performance outcomes?” Three types of analyses were conducted to examine the relationships between the interface and performance outcomes, using quantitative data collected on personnel involvement and task interaction during capital project development.

5.1 BACKGROUND

Direct involvement by the owner organization during capital project definition and execution is widely recognized as a critical success factor (NRC 2002; CII 2003a; NRC 2005; CII 2006, Morrow 2011). CII RT 204 (2006) confirmed that owner involvement is a critical factor for project success. The research team developed an indicator for owner involvement that measured the level and quality of owner input into the project process including owner oversight, owner participation, and decision-making. RT 204 found that owner involvement is a critical success factor contributing to cost, schedule, business, quality, and safety success. Particularly, the research team emphasized the need to establish an appropriate level of involvement for the project and that direct involvement in project reviews and specific management programs such as safety program are critical.

An owner organization consists of various management personnel entities who are involved in a project. They are typically categorized into three groups: senior management personnel, functional management personnel, and project management personnel. Project management personnel are those who are directly involved in a project while senior and functional management personnel are business executives and functional managers who are not necessarily directly involved in all functions of a project. When senior and functional management personnel interface on a project task, managerial interfaces are created between the project unit and the business unit.

5.2 PROPOSITIONS

This section offers research positions linking the second research question to the effects of the business-project interface on capital project performance. When the interface exists, management personnel play various direct and indirect roles. This section reviews arguments about the effects of personnel involvement on performance outcomes, and presents the need for intervening variables to moderate the effects of personnel involvement on performance in terms of task interaction.

Several studies in project management literature have found that the involvement of the owner's business unit personnel in a project has a positive relationship with performance. Kerzner (1992) asserted that project management success criteria can be envisioned as a three-legged stool consisting of the project manager, functional manager, and senior management. He emphasized that if any of them fail, the project would have difficulties being successful. Despite the fact that the involvement of management

personnel has been recognized as important, only a few studies exist that attempted to quantitatively investigate the relationships between personnel involvement and performance. Zwikael (2008) investigated the relationships between top management support and performance and concluded that effective executive involvement can significantly improve project success including cost, schedule, overall project performance, and customer satisfaction.

Senior management involvement is recognized as one of the critical success factors for a capital project (Fortune and White, 2006; Zwikael, 2008). Kerzner (1992) asserted that the executives are expected to interface with capital projects in terms of front end planning and objective setting, conflict resolution, priority setting, and project sponsorship. Fortune and White (2006) identified support from senior management and project sponsorship/championship as critical success factors for information system projects.

Zwikael (2008) considered top management support one of the critical success factors in project management and asserted that effective executive involvement can significantly improve project success including cost, schedule, overall project performance, and customer satisfaction. He provided seventeen top management support practices affecting project success in different industries and different countries and found that top management support practices had statistically significant relationships with project success, particularly, in the engineering and construction industries. He emphasized that senior managers need to focus on top management support processes for better performance outcomes. Bryde (2008) investigated the impacts of project

sponsorship on the success of the project. It was found that the greater the project sponsorship effort, the greater the perceived level of project success. Accordingly, the first proposition claims that more involvement by senior management leads to better performance outcomes, as follows:

> *Proposition 2-1: The more the owner's management personnel interface with a capital project, the better the performance outcome.*

On the other hand, the involvement of business unit personnel on a project is not always positive. Kernzer (1992) argued that senior management involvement can be negative when executive do not get accurate information from the project manager as to project status, particularly during project execution. The involvement of functional management personnel exposes potential conflicts on the interface (Kerzner 1992; Struckenbruck 1998). Struckenbruck (1998) argued that the project/functional interfaces that are created by the involvement of functional management personnel are natural conflict situations since many of the goals and objectives of project and functional management are so very different. If managing relationships with the functional manager fails, it is problematic and negative on project success (Struckenbruk 1998). The Project Management Body of Knowledge (PMBOK) Guide identifies senior and functional management personnel as internal stakeholders. A stakeholder is defined as "persons or organizations, who are actively involved in the project or whose interests may positively or negatively affecte deliverables, and the project team member" (PMI, 2008). It is

pointed out that a project can be perceived as having both positive and negative impacts by stakeholders' involvement (PMI 2008).

To avoid the negative impacts of business unit personnel involvement, Stuckenbruck (1998) asserted that cooperation and negotiation are key to successful decision making across the project/functional interface. He also argued that the project manager and functional manager should communicate with each other on at least a daily basis, and usually more often to avoid conflicts. The PMBOK Guide (2008) emphasizes that the project manager must identify and manage the expectation of the stakeholders, who may have different or conflicting objectives, and to ensure that the project team interacts with stakeholders in a professional and cooperative manner. Pitagorsky (1998) emphasized that the collaborative relationship between function managers and project managers is critical to effective project performance. Therefore, the second proposition is as follows:

> *Proposition 2-2: The more the project unit personnel interact with business unit personnel for work functions during the development of a capital project, the better the performance outcomes.*

Senior management personnel play an important role in coordinating the relationships between project and functional units. Kerzner (1992) pointed out that senior management needs to provide advice and guidance to the project manager, as well as to provide encouragement to the functional managers to keep their support throughout a project (Kerzner 1992). In addition, Stuckenbruk (1998) asserted the need for senior

management involvement in order to resolve conflicts and balance power between the project manager and functional manager. In addition, Zwikael (2008) asserted that the existence of interactive inter-departmental project groups is a critical top management support process for project success. Senior management involvement facilitates the interaction between the business and project units. Consequently, the third research proposition is addressed based on the statements above.

> *Proposition 2-3: The more the business unit personnel interface with a capital project, the better the interaction between the business unit and the project unit. Projects with high involvement of business unit personnel and high interaction between business and project units have better performance outcomes.*

Based on the research propositions, this research examined not only the direct effects of personnel involvement but also interaction effects of personnel involvement and task interaction as intervening variables between personnel involvement and performance outcomes. The following section explains the data preparation and analysis procedures employed to answer the research propositions linking with the second research question.

5.3 SIMPLE CORRELATION

This section presents the data analysis methods utilized to measure associations between variables. As usual, selection of an appropriate data analysis method for the

measure of association and its test of significance for comparing groups depends on the characteristics of the variables such as the nature of the distribution, the number of groups or variable to be compared, the nature of groups or samples, the level of measurement of variables, and the number of categories of variables (de Vaus 2002). de Vaus (2002) recommended nonparametric tests for small samples because parametric tests on small samples will be unreliable. This research considered the characteristics of the variables used and selected an appropriate test of significance for each analysis through comparing nonparametric tests for nominal or ordinal measure of association because the sample size is less than 100. First, the data pre-processing described how to deal with the data at various levels of measurement. Then, data analysis methods used in this research are summarized below.

This section describes the analysis results regarding the effects of the business-project interface on performance outcomes. The section consists of four subsections: 1) relationships between personnel involvement and performance, 2) relationships between task interaction and performance, 3) interaction effects of personnel involvement and task interaction on performance, and 4) interaction effects of personnel involvement and best practice on performance.

5.3.1 Data Pre-Processing

CII performance metrics are basically designed with either interval or ordinal levels of measurement. The metrics for project cost growth, project schedule growth, and

change cost factors are continuous variables. The achievement of business objectives is an ordinal variable measured by 7-value Likert scale. Ordinal variables can be regarded as continuous variables if there are enough variation (de Vaus, 2002). Sometimes, the distribution of a variable has too much variation or it is skewed, the analysis using the variable fails to obtain reliable results (de Vaus 2002). Therefore, the metrics used in this research were transformed into binary variables, as can be seen in Table 5.1.

The cost growth metric was transformed into a binary variable with a category for better and worse performance, based on the criteria of "Within Budget" (<=0) and "Over Budget" (>0). The schedule growth metrics were transformed based on the criteria of "Ahead of Schedule" (<=0) and "Behind Schedule" (>0). The change cost factor was categorized into "Below Median" and "Above Median," because the smaller value indicates better performance outcomes. The achievement of business objectives was transformed based on the criteria of "Above Median" and "Below Median." In these metrics, the larger value indicates better performance outcomes.

Table 5.1 Categories of Metrics of Performance Outcomes

Performance Outcomes	Performance Metrics	Original Level of Measurement	Transformed Level of Measurement	
			Better Category Criterion	Worse Category Criterion
Cost	Project Cost Growth	Interval	Within Budget (<= 0)	Over Budget (> 0)
Schedule	Project Schedule Growth	Interval	Ahead Schedule (<= 0)	Behind Schedule (> 0)
Change	Cost Change Factor	Interval	Below Median	Above Median
Business	Achievement of Business Objectives	Ordinal	Above Median (Extremely Successful)	Below Median (Others)

5.3.2 Measure of Association

As stated in the questionnaire development section, the level of involvement of management personnel was obtained by categorizing the work-hours expended on a given project. The level of measurement of personnel involvement consists of the following ordinal categories: 0 hours, 1 – 40 hours, 41 – 400 hours, and > 400 hours. The level of task interaction was designed to measure how much the project unit interacts with the business unit, based on the spontaneity and frequency of collaboration between them. The measurement on task interaction has ordinal categories from “no interaction” (level 0) to “very good interaction” (level 5).

The levels of measurement for involvement and interaction were transformed from ordinal data to dichotomous data. As usual, the median value has been widely used in a number of project success studies as a criterion for transforming continuous or ordinal data into dichotomous data (CII 2011). However, considering skewness and variance in level of involvement, the median may not be appropriate as a criterion. This research sought an alternative approach to identify the optimal level of involvement, maximizing the level of association between independent and dependent variables at a statistically significant level.

Suk (2012) used contingency table analysis to identify minimum levels of implementation required for project management practices to lead to better performance. A statistically significant association was established using the phi coefficient, chi-square test and Fisher’s exact test. The minimum level of implementation was determined if the result of the chi-square test or Fisher’s exact test for significance was statistically

significant at the 0.1 significance level. This approach was based on the concept that each minimum level of implementation of project management effort varies, depending on performance.

Adopting Suk's concept, this research used contingency table analysis to determine the optimal level in terms of personnel involvement and task interaction. Among the two dichotomous variables, the categories of the dependent variables were determined based on the given criteria. Independent variables were determined by contingency table analysis when the level of association between two dichotomous variables is maximized. The phi coefficient was used to measure associations which can be applied to two dichotomous variables. The phi coefficient in the contingency table analysis and test of significance will be explained in the following section.

Basically, correlation coefficients are a class of statistics designed to measure the extent to which variables are related. Correlation coefficients provide an efficient means of detecting and summarizing relationships between variables (de Vaus 2002). There are a large number of different correlation coefficients which are designed to account for matters such as the level of measurement of each of the variables and number of categories of the variables (de Vaus 2002). This research adopted the bivariate analysis to measure the relationship between two binary/dichotomous variables using the phi coefficient. The phi coefficient is a measure of association for two binary variables and it is similar to the Pearson correlation coefficient in its interpretation.

Table 5.2 Contingency Table for Relationship between Personnel Involvement and Performance Outcomes

		Performance Outcomes		Total
		Worse	Better	
Level of Involvement	High Involvement (>= *k*)	*a*	*b*	*a*+*b*
	Low Involvement (< *k*)	*c*	*d*	*c*+*d*
Total		*a*+*c*	*b*+*d*	*a*+*b*+*c*+*d*

The phi coefficient is actually a product-moment coefficient of correlation and is a variation of Pearson's definition of *r* when the two states of each variable are given values of 0 and 1, respectively (Agresti, 2013). The phi coefficient was designed for the comparison of dichotomous distributions in the 2×2 contingency table. For example, the contingency table for relationship between personnel involvement and performance outcome is shown in Table 5.2. The level of personnel involvement is categorized into two groups by optimal criterion (*k*) which can differentiate the two groups of personnel involvement for better and worse performance outcome and has a maximum phi coefficient.

If a, b, c, and d represent the frequencies of observation, then phi coefficient (ϕ) is determined by the relationship and is calculated as following equation.

$$\phi = \frac{ad - bc}{\sqrt{(a+b)(c+d)(a+c)(b+d)}}$$

This coefficient bears a relationship to χ^2, where

$$\phi^2 = \frac{\chi^2}{a+b+c+d}$$

The significance test indicates the probability that results found in a sample are due to sampling error, or reflect patterns in population from which the sample is drawn (de Vaus, 2002). de Vaus (2002) asserted that the probability level of a significance test is mainly affected by three factors which are sample size, diversity within the population, and effect magnitude. Due to these three factors, it is not possible to draw unambiguous conclusions about the nature of any correlation. Particularly, the size of a correlation coefficient only indicates the relationship between two variables in a sample (de Vaus 2002). The test of significance and the associated probability levels are required to make an inference of the relationship. Therefore, sample size needs to be considered on any correlation coefficient since sample size provides an important context in which to interpret a correlation. de Vaus (2002) pointed out that almost no relationships in small samples were statistically significant because small samples are subject to high degrees of sampling error. Therefore, in a test for significance on a small sample size, the significance level needs to be conservatively interpreted.

This research uses relatively small samples, 42 or fewer. To obtain accurate and reliable results, the significance levels calculated from the nonparametric test procedures were provided through the asymptotic method, which means *p* values are estimated based on the assumption that the data, given a sufficiently large sample size, conform to a particular distribution (Mehta and Patel, 2011). However, because some variables used in the research have a small sample size, the asymptotic method may fail to produce reliable results. To avoid unreliable results, it is preferable to calculate a significance level based on the exact distribution of the test statistic. The exact method provides an accurate *p*

value without relying on assumptions that may not be met by the data (Mehta and Patel, 2011). The IBM SPSS statistical package provided the test for calculating reliable significance levels (Mehta and Patel, 2011). The exact test for the phi coefficient is usually performed quickly with sample sizes (N) of less than or equal to 30 and the number of rows or columns in the contingency table is less than or equal to 3 (Mehta and Patel, 2011).

5.3.3 Relationships between Personnel Involvement and Performance

The phi coefficient (ϕ) was used to measure the association between personnel involvement and performance. The descriptive statistics presented in the previous chapter show that the most personnel involvement had statistically significant relationships with project size. Therefore, the associations between personnel involvement and performance are provided in terms of project sized from $5MM-$50MM, and greater than $50MM. The associations of projects with costing less than $5MM were not included because the number of samples in this cost category was fewer than 10. All associations are examined at the 0.1 significance level.

As shown in Table 5.3, most of the phi coefficients between personnel involvement and cost performance were positive, indicating that more involvement of management personnel is associated with better cost performance. Particularly, the association between personnel involvement and cost performance in the >$50MM cost category were slightly stronger than those in the $5MM-$50MM cost category. However,

no statistically significant association between personnel involvement and performance was found in all cost categories.

Table 5.3 Phi Coefficient between Personnel Involvement (PI) and Cost Performance

Management Personnel		Cost Performance		
			Cost Category	
		All	$5MM-$50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	0.108	0.203	0.228
	Business Unit Manager	0.108	-0.203	0.228
	Project Sponsor	0.141	0.171	0.433
Functional Management Personnel	Accounting Manager	0.191	0.139	0.337
	Finance Manager	0.154	0.171	0.228
	Marketing/Sales Manager	-0.014	0.139	-0.365
	Human Resource Manager	0.224	0.139	0.433
	Information Technology Manager	0.203	0.257	0.350
	Facility/Plant Manager	0.108	0.099	0.158
	Contract & Legal Manager	0.239	0.245	0.300
	Operations/ Production Manager	0.224	0.139	0.537
	Portfolio/Program Manager	0.154	0.203	0.184
Project Management Personnel	Project Manager	0.194	N.A.	N.A.
	Project Controls Manager	-0.049	0.033	-0.184
	Engineering Manager	0.031	0.203	-0.025
	Engineering Team Lead	-0.103	-0.054	-0.058
	Procurement Manager	0.232	0.171	0.433
	Construction Manager	-0.008	-0.054	N.A.
	QA/QC Manager	0.115	0.182	0.158
	HSE Manager	0.138	-0.099	0.365

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 11 to 41
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

Table 5.4 demonstrates that most of the phi coefficients were positive, indicating that more involvement of management personnel is associated with better schedule performance. The involvements of the finance manager, Project Controls Manager, Engineering Team Lead, and QA/QC Manager were found to have statistically significant

association with schedule performance at the 0.1 level in overall and $5MM-50MM cost category.

Table 5.4 Phi Coefficient between PI and Schedule Performance

Management Personnel		Schedule Performance		
			Cost Category	
		All	$5MM-$50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	0.229	-0.196	0.365
	Business Unit Manager	0.229	0.196	0.365
	Project Sponsor	0.217	0.354	*0.693
Functional Management Personnel	Accounting Manager	0.208	*0.612	0.539
	Finance Manager	**0.354	*0.707	0.415
	Marketing/Sales Manager	0.000	-0.134	-0.228
	Human Resource Manager	0.236	-0.134	0.350
	Information Technology Manager	0.229	-0.196	0.527
	Facility/Plant Manager	0.302	0.468	0.337
	Contract & Legal Manager	0.118	0.468	0.158
	Operations/ Production Manager	0.239	0.302	0.337
	Portfolio/Program Manager	0.037	-0.134	-0.184
Project Management Personnel	Project Manager	-0.180	N.A.	N.A.
	Project Controls Manager	**0.335	*0.707	0.228
	Engineering Manager	0.302	0.468	0.228
	Engineering Team Lead	**0.331	*0.612	0.433
	Procurement Manager	0.258	0.408	0.433
	Construction Manager	0.239	0.354	N.A.
	QA/QC Manager	*0.295	*0.707	0.527
	HSE Manager	0.180	*0.612	0.228

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 11 to 39
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

Table 5.5 shows that most of the phi coefficients were positive, indicating that more involvement of management personnel is associated with better change performance in the overall dataset. In particular, the more involvements of the Business Unit Manager, Project Sponsor, and Facility/Plant Manager were significantly associated with better change performance at the 0.1 significance level.

Table 5.5 Phi Coefficient between PI and Change Performance

Management Personnel		Change Performance		
			Cost Category	
		All	$5MM-$50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	0.162	-0.320	0.174
	Business Unit Manager	*0.282	0.320	0.333
	Project Sponsor	*0.305	-0.218	0.111
Functional Management Personnel	Accounting Manager	0.091	-0.218	0.488
	Finance Manager	-0.006	-0.218	0.408
	Marketing/Sales Manager	0.162	-0.218	0.174
	Human Resource Manager	0.091	-0.218	0.258
	Information Technology Manager	0.162	0.000	0.174
	Facility/Plant Manager	*0.289	-0.167	0.408
	Contract & Legal Manager	0.107	-0.218	0.488
	Operations/ Production Manager	0.165	-0.123	0.333
	Portfolio/Program Manager	0.117	0.080	0.333
Project Management Personnel	Project Manager	0.082	N.A.	N.A.
	Project Controls Manager	0.246	-0.389	0.111
	Engineering Manager	0.135	-0.218	0.098
	Engineering Team Lead	0.026	-0.431	0.258
	Procurement Manager	-0.009	-0.218	0.111
	Construction Manager	0.077	-0.123	N.A.
	QA/QC Manager	0.138	-0.272	0.111
	HSE Manager	0.248	0.218	0.333

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 11 to 37
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.
.

Table 5.6 shows that most associations between personnel involvement and business performance are positively associated. The involvements of the Project Sponsor, Facility/Plant Manager, Operations/Production Manager, Engineering Team Lead, and Procurement Manager had a statistically meaningful association with business

performance at the 0.1 significance level. Particularly in the $5MM-$50MM cost category, the involvements of Finance Manager, Facility/Plant Manager, Engineering Manager, and Engineering Team Lead were statistically significant at 0.1.

Table 5.6 Phi Coefficient between PI and Business Performance

Management Personnel		Business Performance		
			Cost Category	
		All	$5MM - $50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	0.234	0.207	0.272
	Business Unit Manager	0.033	0.026	-0.250
	Project Sponsor	*0.365	0.378	0.408
Functional Management Personnel	Accounting Manager	0.234	0.258	0.272
	Finance Manager	0.289	*0.559	0.272
	Marketing/Sales Manager	N.A.	N.A.	N.A.
	Human Resource Manager	0.115	0.207	0.089
	Information Technology Manager	0.258	0.344	0.272
	Facility/Plant Manager	*0.393	*0.559	0.272
	Contract & Legal Manager	0.367	0.447	0.250
	Operations/ Production Manager	*0.293	0.207	0.583
	Portfolio/Program Manager	0.115	0.207	0.089
Project Management Personnel	Project Manager	N.A.	N.A.	N.A.
	Project Controls Manager	0.258	0.447	0.356
	Engineering Manager	0.238	*0.519	0.250
	Engineering Team Lead	*0.348	*0.519	0.356
	Procurement Manager	*0.346	0.258	0.535
	Construction Manager	-0.115	-0.141	N.A.
	QA/QC Manager	0.244	0.244	0.408
	HSE Manager	0.067	0.043	0.089

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 10 to 24
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

From the results of the associations between personnel involvement and performance outcomes, the following findings are provided. First, most of the

associations between personnel involvement and performance outcomes are positive over a certain level of involvement, indicating that more interface by the owner's key personnel on a capital project are associated with better performance. That is, personnel involvement has a directly positive influence on better performance outcomes, particularly in terms of schedule, change, and business performance, with statistically significant results. Senior management involvement also directly influences on better performance outcomes. For example, the more the business unit manager interfaces with a project, the better the change performance. In addition, the more the project sponsor interfaces with a capital project, the better schedule performance, change performance, and business performance. These findings support the importance of the roles of senior management and project sponsorship, as found in previous studies (Kerzner, 1992; Fortune and White, 2006; Zwikael, 2008).

Among functional management personnel, the involvement of the finance manager who supports project funding is significantly associated with schedule and business performance. Timely and proper funding is critical to enable a capital project to be done within planned schedule (Kerzner, 1992; Merrow, 2011). This also leads to the achievement of business objectives. Therefore, it is reasonably concluded that more support from a finance manager can lead to better schedule performance. A statistically significant relationship was found for the facility/plant manager and better change and business performance. The operations/production manager had a statistically significant relationship with better business performance.

Among project management personnel, control personnel contributed most to schedule performance. Additionally, the project control manager, engineering team lead, and QA/QC manage were significantly associated with better schedule performance. The projects in which engineering and procurement personnel were more involved had better business performance.

Table 5.7 summarizes the optimal level of involvement to maximize the association between personnel involvement and performance outcome. The optimal level indicates that if management personnel interface with a project at the given level, the personnel involvement contributes significantly to improvement of the performance outcome. The level of involvement ranges from greater than 0 hours to greater than 400 hours. The level of involvement at which the association becomes statistically significant at the 0.1 significance level is marked.

Table 5.7 Optimal Involvement Level of Management Personnel

Management Personnel		Cost			Schedule			Change			Business		
		All	$5M-$50M	>$50M	All	$5M-$50M	>$50M	All	$5M-$50M	>$50M	All	$5M-$50M	>$50M
Senior Management Personnel	Chief Executive Officer	> 40	> 0	> 40	> 40	> 0	> 40	> 40	> 0	> 40	> 0	> 0	> 0
	Business Unit Manager	> 400	> 0	> 400	> 400	> 0	> 400	> 40*	> 0	> 40	> 40	> 40	> 0
	Project Sponsor	> 40	> 40	> 400	> 400	> 40	> 400*	> 0*	> 400	> 40	> 40*	> 40	> 400
Functional Management Personnel	Accounting Manager	> 400	> 400	> 400	> 40	> 40*	> 400	> 400	> 400	> 40	> 400	> 0	> 400
	Finance Manager	> 400	> 0	> 400	> 40**	> 40*	> 40	> 400	> 400	> 0	> 0	> 0*	> 400
	Marketing/ Sales Manager	> 0	> 0	> 0	> 0	> 0	> 0	> 40	> 0	> 0	N.A.	N.A.	N.A.
	Human Resource Manager	> 40	> 0	> 40	> 0	> 0	> 0	> 40	> 0	> 40	> 0	> 0	> 0
	Information Technology Manager	> 40	> 40	> 0	> 400	> 40	> 0	> 400	> 0	> 400	> 0	> 0	> 400
	Facility/Plant Manager	> 40	> 40	> 40	> 0	> 40	> 0	> 400*	> 40	> 40	> 40*	> 40*	> 400
	Contract & Legal Manager	> 40	> 40	> 40	> 40	> 40	> 40	> 0	> 400	> 40	> 40	> 40	> 40
	Operations/ Production Manager	> 400	> 400	> 40	> 0	> 40	> 0	> 400	> 40	> 400	> 400*	> 400	> 40
	Portfolio/Program Manager	> 400	> 400	> 0	> 0	> 40	> 0	> 40	> 40	> 0	> 0	> 0	> 0
Project Management Personnel	Project Manager	> 400	N.A.	N.A.	> 400	N.A.	N.A.	> 400	N.A.	N.A.	N.A.	N.A.	N.A.
	Project Controls Manager	> 40	> 40	> 400	> 400**	> 400*	> 40	> 0	> 400	> 400	> 400	> 40	> 400
	Engineering Manager	> 400	> 400	> 400	> 0	> 40	> 0	> 400	> 400	> 400	> 0	> 0*	> 400
	Engineering Team Lead	> 400	> 0	> 400	> 40**	> 400*	> 400	> 400	> 0	> 400	> 40*	> 0*	> 400
	Procurement Manager	> 0	> 40	> 400	> 40	> 40	> 40	> 400	> 400	> 40	> 400*	> 40	> 400
	Construction Manager	> 400	> 0	N.A.	> 0	> 400	N.A.	> 400	> 400	N.A.	> 0	> 0	N.A.
	QA/QC Manager	> 40	> 40	> 40	> 40*	> 400*	> 40	> 0	> 0	> 40	> 400	> 400	> 0
	HSE Manager	> 40	> 400	> 0	> 400	> 400*	> 0	> 0	> 0	> 400	> 400	> 400	> 400

****** indicates exact *p*-value is less than 0.05 ***** indicates exact *p*-value is less than 0.1
Sample size for each correlation range from 10 to 41
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

5.3.4 Relationships between Task Interaction and Performance

As presented in the previous section, various management personnel in an owner organization interface with a capital project, and most of their involvement is positively associated with better performance outcomes. Practically, most major tasks which are critical for project planning and execution require interaction, collaboration, and cooperation between various business and project functions. This research measures their interaction between business and project unit and examines the relationships between task interactions and performance outcomes.

Table 5.8 illustrates the phi coefficients between task interaction and cost performance. Most associations between planning task interactions and cost performance are positive, indicating that the more the business and project units interact with each other, the better the cost performance. Among the planning task interactions, increased interaction on tasks such as financial appraisal, manufacturing objectives criteria, business objectives, and project scope in the front end planning phase had a significantly positive association with better cost performance at the 0.1 significance level. Particularly in the >$50MM cost category, the interaction during financial appraisal was significantly associated with cost performance at the 0.1 significance level.

Most associations between execution task interactions and cost performance were also positive. The interactions of project management, funding requests, and HSE had a statistically positive relationship with better cost performance at the 0.1 significance

level. Particularly, in the $5MM-$50MM cost category, project management and HSE were the significantly associated interactions with better cost performance.

Table 5.8 Phi Coefficient between Task Interaction (TI) and Cost Performance

Phase		Work Function	Cost Performance		
			All	Cost Category	
				$5MM-$50MM	> $50MM
			Phi Coefficient	Phi Coefficient	Phi Coefficient
Business Planning		Corporate Goal Setting	0.100	-0.228	0.184
		Strategic Planning	0.040	-0.228	0.101
		Market Analysis	0.195	-0.058	-0.169
		Priority Setting	0.276	0.182	0.350
		Opportunity Identification	-0.171	-0.346	-0.100
		Capital Budgeting	0.125	-0.346	0.365
Front End Planning	Feasibility Analysis	Financial Appraisal	**0.448	0.272	*0.539
		Economic Feasibility Study	0.217	0.167	-0.239
		Technical Feasibility Study	0.218	0.019	-0.350
		Social Impact Analysis	0.205	0.000	-0.189
		Environmental Impact analysis	0.262	0.218	0.293
	Concept Development	Manufacturing Objectives Criteria	*0.323	0.443	0.169
		Business Objectives	*0.275	0.171	0.098
		Basic Data R&D	0.131	0.300	-0.350
		Project Scope	**0.239	0.019	0.158
		Value Engineering	0.204	0.228	-0.365
	Detailed Scope	Site Information	0.250	0.228	0.220
		Procurement Strategy	0.171	0.019	-0.220
		Project Execution Plan	-0.219	-0.251	-0.415

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1

Table 5.8 Phi Coefficient between TI and Cost Performance (Continued)

Phase	Work Function	Cost Performance		
			Cost Category	
		All	$5MM-$50MM	$50MM
		Phi Coefficient	Phi Coefficient	Phi Coefficient
Project Execution	Project Management	*0.286	*0.523	-0.318
	Estimating	0.198	0.251	0.025
	Cost Management	0.114	0.245	-0.098
	Accounting	0.211	-0.078	-0.220
	Scheduling	0.136	-0.119	0.025
	Communication	0.236	-0.171	0.101
	Management Information Systems	0.183	0.073	0.098
	Risk Management	0.144	-0.337	-0.220
	Contracting	0.179	0.277	-0.250
	Permitting	-0.136	-0.033	-0.350
	Funding Requests	*0.313	N.A.	0.365
	Change Management	0.250	0.346	0.025
	HSE	**0.375	*0.461	0.101
	Claims Management	0.183	-0.316	-0.293
	QA/QC	0.019	-0.302	-0.220
	Human Resource Management	0.311	-0.293	0.598
	Detailed Engineering	-0.125	-0.228	0.184
	Procurement	-0.171	0.033	-0.350
	Construction	0.040	0.033	-0.098
	Startup/Commissioning	-0.120	-0.308	-0.220
Project Close-out		-0.157	-0.228	-0.220

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1

Table 5.9 describes the phi coefficients between task interaction and schedule performance. A few associations between planning task interactions and schedule performance were positive, but no significant association was found in the overall data set. In the $5MM-$50MM cost category, the interaction of priority setting was statistically positive associated with schedule performance at the 0.1 significance level. Some interactions in front end planning such as economic feasibility analysis, technology feasibility analysis, social impact analysis, basic data R&D, and procurement Strategy

were positively associated with schedule performance, but those associations were not statistically significant. Only a few associations between execution task interactions and schedule performance are positive in overall data set. However, there is no statistically significant association. On the other hand, in the $5MM-$50MM cost category, most associations between task interactions and schedule performance are positive, but the interaction of risk management and startup/commissioning were statistically significant.

Table 5.9 Phi Coefficient between TI and Schedule Performance

			Schedule Performance		
				Cost Category	
			All	$5MM-$50MM	$50MM
Phase		Work Function	Phi Coefficient	Phi Coefficient	Phi Coefficient
Business Planning		Corporate Goal Setting	-0.227	0.408	-0.300
		Strategic Planning	-0.203	-0.408	-0.101
		Market Analysis	-0.276	0.463	-0.598
		Priority Setting	0.175	*0.535	-0.184
		Opportunity Identification	-0.234	-0.468	-0.559
		Capital Budgeting	-0.211	-0.612	0.350
Front End Planning	Feasibility Analysis	Financial Appraisal	0.107	-0.671	0.537
		Economic Feasibility Study	0.208	0.234	-0.293
		Technical Feasibility Study	0.000	0.354	0.184
		Social Impact Analysis	0.156	0.750	-0.378
		Environmental Impact analysis	-0.140	-0.603	0.371
	Concept Development	Manufacturing Objectives Criteria	-0.318	-0.603	0.357
		Business Objectives	-0.304	-0.612	0.220
		Basic Data R&D	-0.167	0.612	-0.350
		Project Scope	-0.254	-0.829	0.184
		Value Engineering	-0.342	-0.468	-0.220
	Detailed Scope	Site Information	-0.492	-0.707	-0.350
		Procurement Strategy	-0.227	0.408	-0.415
		Project Execution Plan	-0.342	-0.354	-0.415

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1

Table 5.9 Phi Coefficient between TI and Schedule Performance (Continued)

Phase	Work Function	Schedule Performance		
			Cost Category	
		All	$5MM-$50MM	$50MM
		Phi Coefficient	Phi Coefficient	Phi Coefficient
Project Execution	Project Management	-0.417	-0.468	-0.350
	Estimating	-0.342	-0.408	-0.415
	Cost Management	-0.328	-0.468	-0.415
	Accounting	0.134	0.389	-0.415
	Scheduling	-0.119	0.354	-0.300
	Communication	-0.203	-0.535	0.220
	Management Information Systems	0.103	0.452	0.365
	Risk Management	0.281	*0.816	-0.365
	Contracting	0.173	0.389	-0.060
	Permitting	-0.304	0.468	-0.350
	Funding Requests	0.036	0.302	0.025
	Change Management	-0.279	0.468	-0.220
	HSE	0.248	0.354	0.527
	Claims Management	-0.323	0.408	-0.488
	QA/QC	-0.164	0.522	-0.415
	Human Resource Management	-0.239	0.548	0.550
	Detailed Engineering	-0.328	-0.535	-0.415
	Procurement	-0.248	0.408	0.365
	Construction	-0.304	0.468	-0.415
	Startup/Commissioning	-0.305	*0.535	-0.501
Project Close-out		-0.157	0.007	0.408

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1

Table 5.10 demonstrates the phi coefficients between task interaction and change performance. Most task interactions in the front end planning phase are positively associated with better change performance. In overall data set, the interactions of strategic planning, project scope, and procurement strategy are significantly associated with change performance at the 0.1 significance level. However, no significant association was found in the cost category of $5MM-$50MM and >$50MM.

Most of associations between execution task interactions and change performance are positive, and the change performance has statistically significant association with the task interactions for project management, accounting, scheduling, communication, risk management, and HSE at the 0.1 significance level. However, no significant association was found in the cost category of $5MM-$50MM and >$50MM.

Table 5.10 Phi Coefficient between TI and Change Performance

Phase		Work Function	Change Performance		
				Cost Category	
			All	$5MM-$50MM	$50MM
			Phi Coefficient	Phi Coefficient	Phi Coefficient
Business Planning		Corporate Goal Setting	0.267	0.467	0.000
		Strategic Planning	*0.312	0.488	0.400
		Market Analysis	-0.121	-0.314	-0.289
		Priority Setting	0.192	-0.423	0.529
		Opportunity Identification	-0.202	0.258	-0.408
		Capital Budgeting	-0.276	-0.488	0.378
Front End Planning	Feasibility Analysis	Financial Appraisal	0.209	0.354	-0.447
		Economic Feasibility Study	0.260	-0.603	0.258
		Technical Feasibility Study	-0.365	-0.733	-0.674
		Social Impact Analysis	-0.337	-0.975	0.189
		Environmental Impact analysis	-0.284	-0.612	-0.447
	Concept Development	Manufacturing Objectives Criteria	0.266	0.480	0.400
		Business Objectives	0.214	0.313	0.400
		Basic Data R&D	0.308	-0.632	N.A
		Project Scope	*0.284	0.447	-0.258
		Value Engineering	-0.212	-0.244	-0.378
	Detailed Scope	Site Information	-0.160	0.333	-0.529
		Procurement Strategy	**0.361	0.447	-0.378
		Project Execution Plan	0.184	0.313	-0.258

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1

Table 5.10 Phi Coefficient between TI and Change Performance (Continued)

Phase	Work Function	Change Performance		
			Cost Category	
		All	$5MM-$50MM	$50MM
		Phi Coefficient	Phi Coefficient	Phi Coefficient
Project Execution	Project Management	**0.369	0.488	0.378
	Estimating	0.256	0.447	-0.316
	Cost Management	-0.262	-0.447	0.076
	Accounting	*0.325	0.400	0.076
	Scheduling	*0.324	0.488	0.447
	Communication	*0.296	0.467	0.447
	Management Information Systems	0.218	0.327	-0.400
	Risk Management	*0.338	-0.300	0.674
	Contracting	0.218	0.272	-0.060
	Permitting	0.276	0.447	-0.316
	Funding Requests	0.032	-0.447	0.447
	Change Management	-0.312	-0.447	-0.316
	HSE	**0.488	0.447	0.316
	Claims Management	0.224	0.478	0.000
	QA/QC	-0.177	-0.316	0.076
	Human Resource Management	0.283	-0.645	-0.316
	Detailed Engineering	0.160	0.516	0.000
	Procurement	0.184	0.313	-0.316
	Construction	0.276	0.447	0.076
	Startup/Commissioning	-0.145	-0.423	0.378
Project Close-out		0.265	0.467	0.378

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1

Table 5.11 presents the phi coefficients between task interaction and business performance. A few task interactions in both planning and execution phase are positively associated with business performance. Only task interaction for funding requests has statistically significant association with business performance.

Table 5.12 summarized the optimal level of task interaction to maximize the association between task interaction and performance outcome. The optimal level indicates that if the business and project unit interact with each other at the given level, the task interaction contributes significantly improvement of the performance outcome. The level of task interaction ranges from L0 (No Interaction) to L5 (Continuous and Voluntary Collaboration) as stated in the Chapter 3.

Table 5.11 Phi Coefficient between TI and Business Performance

Phase		Work Function	Business Performance		
				Cost Category	
			All	$5MM-$50MM	$50MM
			Phi Coefficient	Phi Coefficient	Phi Coefficient
Business Planning		Corporate Goal Setting	-0.140	-0.378	0.100
		Strategic Planning	-0.250	-0.372	-0.149
		Market Analysis	-0.068	-0.429	0.200
		Priority Setting	-0.361	-0.548	-0.730
		Opportunity Identification	-0.192	-0.389	0.200
		Capital Budgeting	-0.241	-0.344	0.100
Front End Planning	Feasibility Analysis	Financial Appraisal	-0.122	-0.250	0.100
		Economic Feasibility Study	-0.356	-0.316	-0.408
		Technical Feasibility Study	-0.312	-0.337	-0.346
		Social Impact Analysis	-0.225	-0.354	-0.250
		Environmental Impact analysis	-0.233	-0.415	0.000
	Concept Development	Manufacturing Objectives Criteria	-0.124	-0.098	-0.089
		Business Objectives	0.089	-0.189	0.069
		Basic Data R&D	0.000	-0.250	-0.091
		Project Scope	-0.099	-0.141	0.267
		Value Engineering	-0.115	-0.258	-0.100
	Detailed Scope	Site Information	-0.140	-0.559	0.430
		Procurement Strategy	-0.306	-0.519	-0.267
		Project Execution Plan	-0.400	-0.689	0.267
Project Execution		Project Management	0.210	-0.026	0.430
		Estimating	-0.218	-0.519	0.267
		Cost Management	-0.312	-0.519	0.100
		Accounting	-0.357	-0.539	0.100
		Scheduling	-0.312	-0.519	0.311
		Communication	0.089	-0.207	0.261
		Management Information Systems	-0.389	-0.433	-0.346
		Risk Management	-0.331	-0.356	-0.289
		Contracting	-0.257	-0.350	-0.167
		Permitting	-0.306	-0.519	-0.100
		Funding Requests	*0.361	0.189	0.516
		Change Management	0.115	-0.026	0.311
		HSE	0.201	0.372	0.069
		Claims Management	-0.418	-0.625	-0.167
		QA/QC	-0.200	-0.433	0.100
		Human Resource Management	0.258	-0.258	0.167
		Detailed Engineering	-0.361	-0.548	-0.267
		Procurement	-0.218	-0.378	0.100
		Construction	-0.218	-0.519	0.100
		Startup/Commissioning	-0.145	-0.389	-0.261
Project Close-out			-0.250	-0.519	-0.069

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1

Table 5.12 Optimal Level of Task Interaction for Better Performance

Phase		Work Function	Cost Performance			Schedule Performance			Change Performance			Business Performance		
			All	5M-50M	>50M	All	5M-50M	>50M	All	5M-50M	>50M	All	5M-50M	>50M
Business Planning		Corporate Goal Setting	L4	L5	L2	L4	L1	L1	L4	L2	L1	L2	L2	L1
		Strategic Planning	L2	L5	L1	L2	L2	L1	***L2**	L5	L1	L5	L5	L2
		Market Analysis	L4	L1	L1	L1	L2	L1	L2	L2	L1	L4	L2	L1
		Priority Setting	L5	L4	L3	L3	***L4**	L4	L5	L4	L3	L5	L5	L1
		Opportunity Identification	L3	L5	L1	L2	L2	L1	L1	L2	L2	L5	L1	L1
		Capital Budgeting	L3	L5	L1	L4	L4	L5	L1	L1	L5	L1	L4	L4
Front End Planning	Feasibility Analysis	Financial Appraisal	****L1**	L1	*** L1**	L1	L3	L4	L3	L3	L4	L3	L3	L4
		Economic Feasibility Study	L5	L1	L3	L5	L1	L1	L5	L1	L1	L3	L1	L3
		Technical Feasibility Study	L1	L1	L4	L4	L4	L1	L4	L4	L5	L5	L5	L5
		Social Impact Analysis	L4	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1
		Environmental Impact analysis	L1	L4	L1	L4	L3	L3	L1	L1	L4	L3	L3	L3
	Concept Development	Manufacturing Objectives Criteria	***L1**	L1	L4	L1	L4	L5	L5	L5	L1	L4	L4	L1
		Business Objectives	***L4**	L4	L4	L3	L4	L4	L5	L5	L1	L1	L5	L1
		Basic Data R&D	L3	L1	L1	L3	L1	L1	L3	L1	N.A	L1	L1	L1
		Project Scope	****L5**	L4	L4	L4	L4	L4	***L5**	L4	L4	L5	L4	L4
		Value Engineering	L1	L1	L5	L5	L4	L1	L1	L5	L1	L4	L4	L1
	Detailed Scope	Site Information	L1	L1	L3	L3	L3	L1	L1	L3	L4	L5	L5	L5
		Procurement Strategy	L1	L1	L4	L3	L4	L3	****L5**	L5	L1	L5	L5	L3
		Project Execution Plan	L5	L5	L3	L5	L5	L3	L5	L5	L1	L5	L5	L1

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1

Table 5.12 Optimal Level of Task Interaction for Better Performance (Continued)

Phase	Work Function	Cost Performance			Schedule Performance			Change Performance			Business Performance		
		All	5M-50M	>50M	All	5M-50M	>50M	All	5M-50M	>50M	All	5M-50M	>50M
Project Execution	Project Management	***L4**	***L4**	L5	L4	L4	L1	****L5**	L5	L4	L4	L1	L4
	Estimating	L1	L1	L1	L4	L4	L3	L5	L5	L1	L4	L5	L1
	Cost Management	L5	L4	L1	L4	L4	L1	L1	L1	L1	L5	L5	L1
	Accounting	L5	L1	L3	L5	L1	L1	***L5**	L4	L1	L5	L5	L1
	Scheduling	L4	L1	L1	L4	L1	L3	***L5**	L5	L3	L4	L4	L3
	Communication	L4	L5	L1	L4	L4	L4	***L4**	L5	L4	L1	L1	L1
	Management Information Systems	L1	L1	L1	L1	L1	L5	L5	L4	L4	L4	L4	L4
	Risk Management	L3	L5	L4	L5	***L5**	L1	***L1**	L5	L1	L1	L1	L1
	Contracting	L5	L5	L1	L1	L1	L1	L4	L5	L4	L4	L4	L1
	Permitting	L4	L1	L4	L4	L1	L1	L5	L4	L1	L4	L4	L1
	Funding Requests	***L4**	N.A.	L1	L5	L5	L5	L5	L5	L5	***L4**	L5	L4
	Change Management	L5	L4	L1	L3	L5	L1	L4	L4	L1	L1	L4	L4
	HSE	****L4**	***L4**	L3	L4	L4	L4	****L5**	L5	L5	L3	L3	L4
	Claims Management	L5	L1	L4	L4	L1	L4	L2	L2	L1	L5	L2	L1
	QA/QC	L4	L1	L4	L1	L5	L1	L5	L5	L1	L4	L1	L1
	Human Resource Management	L1	L1	L1	L5	L1	L2	L2	L1	L2	L4	L1	L2
	Detailed Engineering	L5	L5	L3	L3	L3	L1	L3	L3	L1	L5	L5	L1
	Procurement	L3	L1	L3	L3	L1	L5	L4	L3	L1	L3	L3	L1
	Construction	L1	L1	L1	L3	L1	L1	L4	L3	L1	L3	L3	L1
	Startup/Commissioning	L4	L1	L4	L1	***L5**	L1	L5	L5	L4	L1	L1	L4
Project Close-out		L1	L5	L1	L2	L1	L1	L4	L4	L2	L5	L4	L1

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1

5.4 Interaction Effects of Involvement and Interaction on Performance

Section 4.3 demonstrated the relationships between personnel involvement and task interaction for various work functions. In this section, the involvement of business unit personnel is positively correlated with task-based interaction which the personnel are involved in. But, the relationships between personnel involvement and task interaction did not always entail a corresponding improvement of performance outcomes. As stated in the previous section, personnel involvement is an essential prerequisite for task interaction. It is reasonably presumed that the interactions between business and project units help individuals to be aligned and integrated on achieving project goals and objectives. To test if combined effects existed between personnel involvement and task interaction, a two-way factorial analysis of variance (ANOVA) was applied to the combination personnel involvement and task interaction.

5.4.1 Interaction Effect Analysis

The two-way factorial ANOVA is actually concerned with the set of mean values that correspond to the sample means. The analysis focuses on the difference in the means of one dependent variable when there are two independent variables. As shown in Figure 5.1, the independent variables are factors such as personnel involvement and task interaction, and the dependent variable are performance outcomes such as cost growth, schedule growth, and change cost factor.

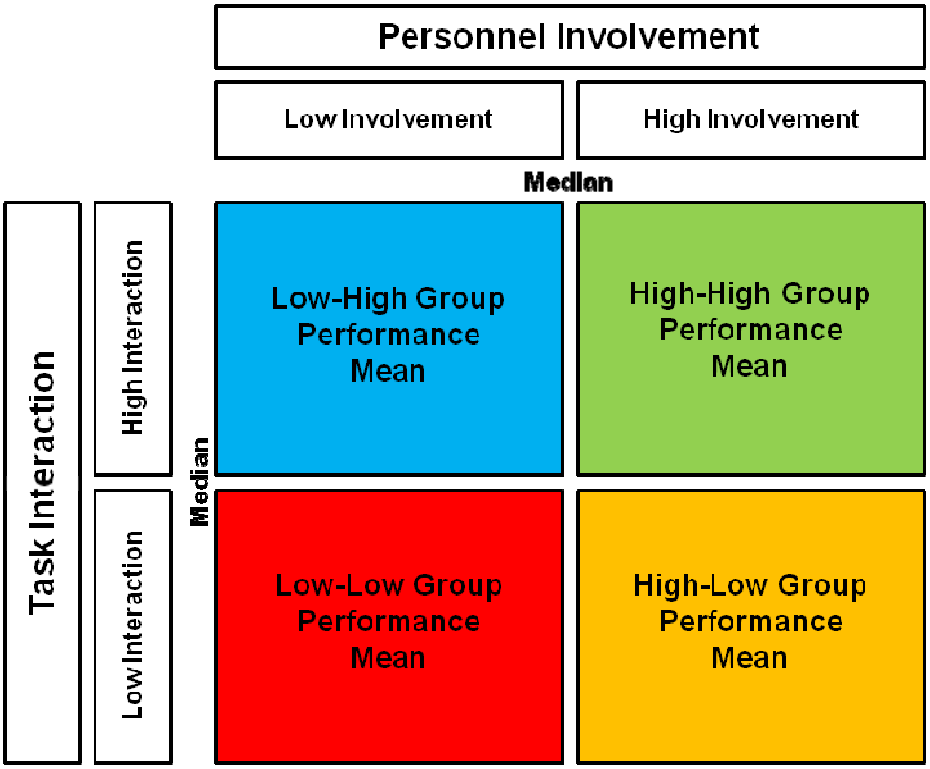


Figure 5.1 Two-way Factorial Design for Interaction Effects Analysis of PI and TI

The two-way ANOVA requires that the dependent variable should be measured on an interval/continuous scale and the factors (independent variables) should be measured on a categorical or discrete scale. Both personnel involvement and task interaction data are ordinal measures which are categorized into high and low groups based on the median value of personnel involvement and task interaction calculated from all projects data. Finally, the data were divided into four quadrants: high-high, high-low, low-high, and low-low as shown in Figure 5.1. It is not necessary for each quadrant to have an equal number of data points because not all projects have all data for personnel involvement and task interaction. Median values are identified based on all projects if they have any personnel involvement and task interaction data. Applying the median to a

set of projects having both data makes the number of data for each quadrant uneven. For each quadrant, the mean value of performance outcome for the projects in the quadrant was calculated.

Using this two-way factorial design, this research intends to confirm the third research proposition: "*Projects with high involvement of business personnel and high interaction between business and project unit have better performance outcomes."* The two-way factorial ANOVA test has several benefits compared to a multiple one-way ANOVA tests. First, the test can avoid any increased risk in committing a Type I error which is the incorrect rejection of a true null hypothesis. Second, the test enables both the main effect and interaction effects to be tested. In addition to investigation on how different levels of the two independent variables affect the dependent variable, this test can also examine whether levels of one independent variable affect the dependent variable in the same way across the levels of the second independent variable. Thus, the results of two-way factorial ANOVA provide the two main effects of each individual independent variable on the dependent variable and one interaction effects of two independent variables on the dependent variable. Moreover, the test allows greater generalizability of the results because factorial designs allow for a much broader interpretation of the results and at the same time provide something meaningful about the results for each of the independent variable separately. This section focuses on the interaction effects of personnel involvement and task interaction on performance outcomes.

There are three main assumptions underlying the two-way ANOVA test because it is a parametric test, and shares similar assumptions to all other parametric tests. Similar to the assumptions underlying the one-way ANOVA, the two-way ANOVA should meet the following assumptions: 1) assumption of independence which means the samples are independent and random samples from defined population; 2) assumption of normality which refers the values on the dependent variable are normally distributed in the population; and 3) assumption of homogeneity of variance which refers the population variance in all cells of the factorial design are equal. For verifying these assumptions, the outliers are detected and removed.

The interaction effects of personnel involvement and task interaction were examined in terms of business unit personnel and the tasks that they are typically involved in. Business unit personnel are not involved in all tasks, but only specific tasks that are associated with their roles and responsibilities. The tasks in which management personnel are involved were identified through the personnel-work function relationship matrix in the previous chapter, and are summarized in Appendix C. The performance outcomes used for investigating interaction effects are cost growth, schedule growth, and change cost factor except achievement of business objectives because the data set for the business performance metric is too small and skewed to be applied to two-way factorial ANOVA. As noted in the previous section, this would likely violate the assumption of normal distribution as the dependent variable.

An interaction between the two factors is presented as two-way ANOVA when the effect of the levels of one factor is not the same across the levels of the other factor. If

there is a statistically significant interaction between the two factors involved in the analysis. An interaction exists to the extent that the difference between the levels of the first factor changes when the level of the second factor moves to another level. There can be various patterns of interaction. This research found interactions that are related to the research proposition as can be seen in Figure 5.2 (a). If more personnel involvement and more task interaction have a positive impact on performance, a comparison of mean values between each quadrant should show that the high involvement/high interaction (high/high) quadrant would have the best performance, and the low involvement/low interaction (low/low) quadrant would have the worst performance. This interaction is the ordinal interaction if the levels of one independent variable never cross at any level of the other independent variable.

Another type of interaction is also observed if there are significant interaction effects between the two variables and that both are required to achieve a beneficial effect, only the high/high quadrant will have the best performance and low/low quadrant won't have the worst performance. This type of interaction is the disordinal interaction if the levels of one independent variable cross at any level of the other independent variable as shown in the Figure 5.2 (b). This interaction effect implies three important points: 1) the high/high quadrant has the best performance compared to others; 2) management personnel who were highly involved, yet with lower interaction between business and project unit have worse performance than those with high involvement and high interaction; 3) the projects with lower or less personnel involvement have worse performance than those with high involvement and high interaction. The ordinal

interaction (high/high - best; low/low - worst) is shown in bold, and the disordinal interaction (high/high - best; low/low - not worst) is shown in italic, and statistically significant interaction is shown in underlined and italic. Most statistically significant interactions have been found among the disordinal interactions.

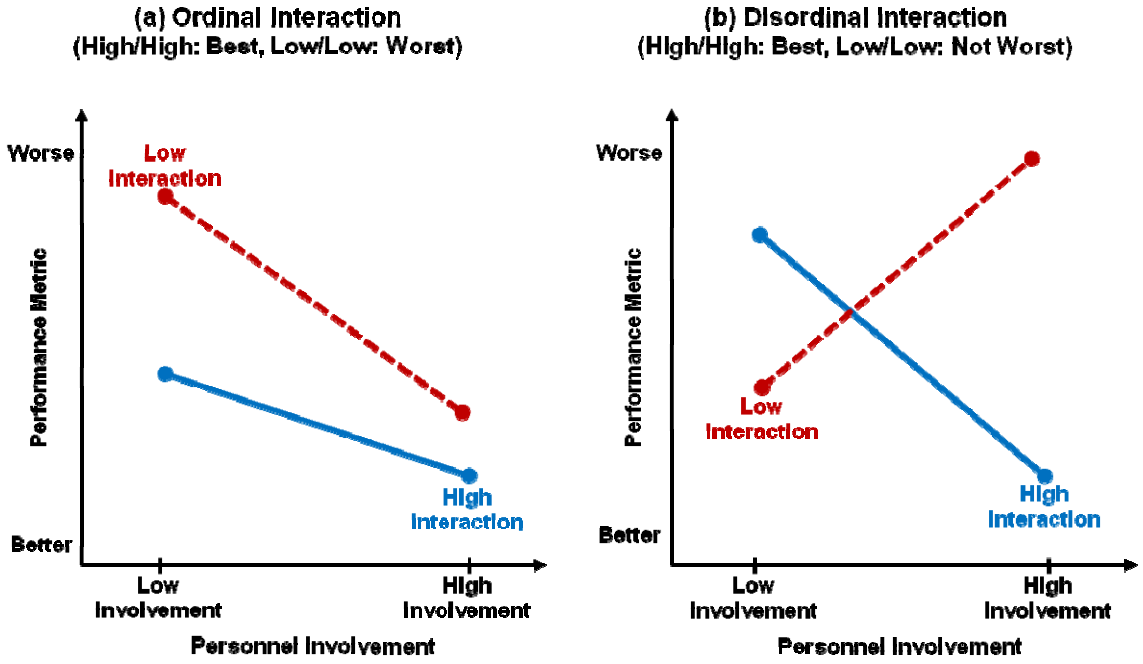


Figure 5.2 Type of Interaction Effects of Involvement and Interaction

For clarity, the combinations of personnel involvement and task interaction that do not meet one of the two interaction patterns are not shown in the tables. In addition, some metrics did not have sufficient data and could not be statistically significant in most combinations. Although some interactions were not statistically significant, the results can be used as possible indicators to show important interaction effects.

5.4.2 Analysis Results

Table 5.13 summarizes the interaction effects of project sponsor involvement and task interaction on performance outcomes in terms of cost, schedule, and change performance. Six ordinal interactions (bold case) of project sponsor involvement and task interaction on cost performance were found on financial appraisal, economic feasibility, social impact analysis, environmental impact analysis, procurement strategy, and detailed engineering. The overall improvement (high/high mean value minus low/low mean value) in each combination is shown in financial appraisal (6.0%), economic feasibility (5.2%), social impact analysis (7.2%), environmental impact analysis (6.9%), procurement strategy (6.9%), and detailed engineering (2.6%), respectively. In addition, five disordinal interactions were also found in the tasks of value engineering, estimating, cost management, change management, and project close-out. Among them, the interaction effect of project sponsor involvement and business project interaction for project close-out on cost performance was statistically significant at the 0.1 level. That is, projects with more involvement by the project sponsor and more interaction on project close-out had significant improvement on cost performance.

Table 5.13 Results of PI of Project Sponsor and TI on Performance (in %)

Task Interaction			Project Cost Growth		Project Schedule Growth		Change Cost Factor	
			Project Sponsor		Project Sponsor		Project Sponsor	
			Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	Financial Appraisal	High Interaction	**-4.1**	**-6.3**				
		Low Interaction	**-0.3**	**-5.0**				
	Economic Feasibility	High Interaction	**-3.8**	**-6.7**				
		Low Interaction	**1.5**	**-3.7**				
	Social Impact Analysis	High Interaction	**-5.9**	**-8.4**	C.T.			
		Low Interaction	**-1.2**	**-3.1**				
	Environmental Impact Analysis	High Interaction	**-3.8**	**-5.4**				
		Low Interaction	**1.5**	**-4.1**				
	Value Engineering	High Interaction	*-3.1*	*-6.0*				
		Low Interaction	*-1.5*	*-1.1*				
	Procurement Strategy	High Interaction	**-3.3**	**-7.2**				
		Low Interaction	**-0.3**	**-2.4**				
Project Execution	Estimating	High Interaction	*-2.4*	*-7.5*				
		Low Interaction	*-2.4*	*-1.1*				
	Cost Management	High Interaction	*-1.3*	*-5.3*				
		Low Interaction	*-3.4*	*-2.9*				
	Change Management	High Interaction	*-2.1*	*-5.7*				
		Low Interaction	*-2.5*	*-1.1*				
	Detailed Engineering	High Interaction	**-2.5**	**-4.8**				
		Low Interaction	**-2.2**	**-4.0**				
Project Close-out		High Interaction	***-0.3***	***-8.3***	***8.7***	***0.5***		
		Low Interaction	***-5.0***	***-2.2***	***1.6***	***9.8***		

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variables on performance is statistically significant at the 0.1 level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Only one disordinal interaction effect of the project sponsor's involvement and task interaction on project close-out for schedule performance has been found. This interaction was statistically significant at the 0.1 level. The schedule performance of the projects with high project involvement and high interaction (high/high quadrant) was 9.3% better than those with high involvement and low interaction (high/low quadrant) and were also 8.2% better than those with low involvement (low/high quadrant). No interaction effect on change performance was been found.

Table 5.14 shows the interaction effects of the accounting manager and project tasks. The involvement of accounting manager was found to have interaction effects on cost performance in terms of finance appraisal, economic feasibility, procurement strategy, project management, and project close-out. Among the interactions, the four ordinal interactions indicate best performance at the high/high quadrant and worst performance at the low/low quadrant. One disordinal interaction effect of the involvement of accounting manager and task interaction for project close-out on cost performance was found, for schedule performance. In particular, the interaction effects from the involvement and interaction of the accounting manager for project close-out on schedule performance was statistically significant at the 0.1 level. The schedule performance of the projects in the high/high quadrant is 11.0% better those in high/low quadrant and was also 8.2% better than those in low/high quadrant. No interaction effect from change performance was found.

Table 5.14 Results of PI of Accounting Manager and TI on Performance (in %)

Task Interaction			Project Cost Growth		Project Schedule Growth		Change Cost Factor	
			Accounting Manager		Accounting Manager		Accounting Manager	
			Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	Financial Appraisal	High Interaction	**-4.5**	**-6.0**				
		Low Interaction	**1.2**	**-5.9**				
	Economic Feasibility	High Interaction	**-4.1**	**-6.6**	C.T.			
		Low Interaction	**-0.3**	**-3.5**				
	Procurement Strategy	High Interaction	**-3.3**	**-7.2**				
		Low Interaction	**-1.2**	**-2.2**				
Project Execution	Project Management	High Interaction	**-2.9**	**-5.9**				
		Low Interaction	**-2.0**	**-2.2**				
	Funding Requests	High Interaction			*4.6*	*2.8*		
		Low Interaction			*6.4*	*16.3*		
Project Close-out		High Interaction	*-0.5*	*-7.1*	***8.7***	***0.5***		
		Low Interaction	*-4.1*	*-2.3*	***3.4***	***11.5***		

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variable is statistically significant at the 0.1 significance level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 5.15 demonstrates the interaction effects of involvement and interaction of the finance manager. When a finance manger interfaces with a project, interaction effects were found for cost performance, specifically on tasks such as finance appraisal, procurement strategy, funding requests, and project close-out. The interaction of involvement of finance manager and financial appraisal is an ordinal interaction which means the high/high quadrant has best performance and low/low quadrant has worst performance. The overall improvement (high/high - low/low) is 3.0%.

Table 5.15 Results of PI of Finance Manager and TI on Performance (in %)

Task Interaction			Project Cost Growth		Project Schedule Growth		Change Cost Factor	
			Financial Manager		Financial Manager		Financial Manager	
			Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	Financial Appraisal	High Interaction	**-4.7**	**-6.0**	*11.9*	*1.4*	*2.5*	*2.3*
		Low Interaction	**-3.0**	**-3.4**	*1.4*	*3.9*	*2.7*	*2.8*
	Business Objectives	High Interaction					*1.9*	*1.8*
		Low Interaction					*3.0*	*3.2*
	Procurement Strategy	High Interaction	*-4.0*	*-7.0*	*10.4*	*0.2*		
		Low Interaction	*-2.0*	*-1.1*	*4.1*	*5.9*		
Project Execution	Funding Requests	High Interaction	*-5.1*	*-7.3*	**5.5**	**0.9**		
		Low Interaction	*-0.7*	*3.7*	**9.6**	**7.5**		
Project Close-out		High Interaction	*-1.9*	*-7.0*	*8.0*	*0.2*		
		Low Interaction	*-4.0*	*-1.1*	*7.2*	*5.9*		

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variable is statistically significant at the 0.1 significance level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

On schedule performance, interaction effects of the finance manager were found on financial appraisal, procurement strategy, funding requests, and project close-out. Among them, the interaction of the finance manager on funding requests tasks was found to be an ordinal interaction. The 8.7% improvement is shown from the difference between high/high quadrant and low/low quadrant. On change performance, the task

interactions for finance appraisal and business objectives had interaction effects with involvement of the finance manager.

Table 5.16 shows the interaction effects of the information technology manager (IT manager) and interaction for the tasks that the IT manager is involved in. The task interaction for management information system was found to have an interaction effect on cost performance from the involvement of the IT manager. The cost performance of the projects in high/high quadrant is 5.8% better than those in high/low quadrant and it is 0.8% better than those in low/high quadrant. No interaction effect was found on schedule performance.

Table 5.16 Results of PI of IT Manager and TI on Performance (in %)

Task Interaction			Project Cost Growth		Project Schedule Growth		Change Cost Factor	
			Information Technology Manager		Information Technology Manager		Information Technology Manager	
			Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	Project Scope	High Interaction					*1.6*	*1.5*
		Low Interaction					*3.3*	*4.0*
	Project Execution Plan	High Interaction					***2.7***	***1.3***
		Low Interaction					***1.3***	***3.5***
Project Execution	Management Information System	High Interaction	*-5.5*	*-6.3*				
		Low Interaction	*-2.7*	*-0.5*				

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variable is statistically significant at the 0.1 significance level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

On change performance, the task interactions for project scope and project execution plan have interaction effects with involvement of IT manager. Among them, the interaction of involvement of IT manager and task interaction for project execution plan was statistically significant at the 0.1 level. The change performance of the projects in the high/high quadrant is 2.2% better than those in high/low quadrant and it is 1.4% better than those in the low/high quadrant.

Table 5.17 demonstrates the interaction effects of involvement of the facility/plant manager and interaction for the task that the facility/plant manager is involved in. Six ordinal interactions were found at the task interactions for site information, procurement strategy, estimating, QA/QC, construction, and project close-out. In addition, five disordinal interactions were found at the task interactions for value engineering, cost management, scheduling, change management, and detailed engineering.

On schedule performance, five disordinal interactions have been shown at the task interactions for scheduling, funding requests, construction, startup/commissioning, and project close-out. Among them, the interactions of involvement of the facility/plant manager and task interactions for construction and project close-out are statistically significant at the 0.1 level. In the task interaction for construction, the schedule performance of the projects in the high/high quadrant is 10.3% better than those in high/low quadrant and it is 11.0% better than those in the low/high quadrant. In addition, the task interaction for project close-out, the schedule performance of the projects in high/high quadrant is 10.9% better than those in high/low quadrant and it is 8.4% better than those in low/high quadrant. On change performance, five ordinal interactions have

been found at the task interaction for manufacturing objectives criteria, project scope, project execution plan, scheduling, and detailed engineering. In addition, four disordinal interactions have been shown at the task interactions for business objectives, site information, communication, and startup/commissioning.

Table 5.17 Results of PI of Facility/Plant Manager and TI on Performance (in %)

Task Interaction			Project Cost Growth		Project Schedule Growth		Change Cost Factor	
			Facility/Plant Manager		Facility/Plant Manager		Facility/Plant Manager	
			Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	Manufacturing Objectives Criteria	High Interaction					**2.2**	**1.3**
		Low Interaction					**3.0**	**2.8**
	Business Objectives	High Interaction					*2.2*	*1.5*
		Low Interaction					*3.0*	*3.2*
	Project Scope	High Interaction					**2.0**	**1.0**
		Low Interaction					**4.3**	**3.3**
	Value Engineering	High Interaction	*-2.2*	*-6.6*				
		Low Interaction	*-2.0*	*-0.3*				
	Site Information	High Interaction	**-2.2**	**-5.0**			*3.0*	*1.8*
		Low Interaction	**-2.0**	**-4.7**			*2.3*	*2.7*
	Procurement Strategy	High Interaction	**-3.8**	**-6.3**				
		Low Interaction	**0.4**	**-3.4**				
	Project Execution Plan	High Interaction					**2.6**	**2.3**
		Low Interaction					**2.7**	**2.4**

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variable is statistically significant at the 0.1 significance level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 5.17 Results of PI of Facility/Plant Manager and TI on Performance (in %) (Continued)

Task Interaction			Project Cost Growth		Project Schedule Growth		Change Cost Factor	
			Facility/Plant Manager		Facility/Plant Manager		Facility/Plant Manager	
			Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Project Execution	Estimating	High Interaction	**-4.4**	**-5.8**				
		Low Interaction	**-0.5**	**-3.4**				
	Cost Management	High Interaction	*-1.7*	*-5.8*				
		Low Interaction	*-2.6*	*-3.7*				
	Scheduling	High Interaction	*-1.5*	*-5.6*	*4.0*	*2.2*	**2.3**	**2.1**
		Low Interaction	*-3.4*	*-3.9*	*8.4*	*12.1*	**3.6**	**2.6**
	Communication	High Interaction					*2.0*	*1.0*
		Low Interaction					*3.1*	*3.8*
	Funding Requests	High Interaction			*4.0*	*3.3*		
		Low Interaction			*6.4*	*16.3*		
	Change Management	High Interaction	*-1.8*	*-6.1*				
		Low Interaction	*-2.2*	*-1.7*				
	QA/QC	High Interaction	**-2.2**	**-6.2**				
		Low Interaction	**-1.9**	**-4.1**				
	Detailed Engineering	High Interaction	*-0.1*	*-6.6*			**2.6**	**2.1**
		Low Interaction	*-4.3*	*-2.1*			**2.7**	**2.6**
	Construction	High Interaction	**-2.5**	**-5.6**	***12.4***	***1.4***		
		Low Interaction	**-1.9**	**-4.1**	***2.0***	***11.7***		
	Startup /Commissioning	High Interaction			*5.9*	*3.8*	*3.5*	*2.1*
		Low Interaction			*5.3*	*14.8*	*2.4*	*2.9*
Project Close-out		High Interaction	**-2.6**	**-5.0**	***8.8***	***0.4***		
		Low Interaction	**-1.6**	**-4.7**	***2.8***	***11.3***		

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variable is statistically significant at the 0.1 significance level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 5.18 summarizes the interaction effects of involvement of contract/legal manager and interaction for the task that the contract/legal manager is involved in. Four ordinal interactions on cost performance have been found at the task interactions for social impact analysis, environmental impact analysis, communication, and change management. In addition, one disordinal interaction was found at the task interactions for risk management.

Table 5.18 Results of PI of Contract/Legal Manager and TI on Performance (in %)

Task Interaction			Project Cost Growth		Project Schedule Growth		Change Cost Factor	
			Contract/Legal Manager		Contract/Legal Manager		Contract/Legal Manager	
			Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	Social Impact Analysis	High Interaction	**-5.9**	**-8.4**	**1.1**	**0.3**		
		Low Interaction	**-1.5**	**-5.5**	**7.0**	**1.9**		
	Environmental Impact Analysis	High Interaction	**-2.3**	**-8.5**				
		Low Interaction	**0.4**	**-7.0**				
Project Execution	Communication	High Interaction	**-2.1**	**-8.1**	*7.0*	*2.0*		
		Low Interaction	**0.0**	**-7.6**	*4.8*	*7.7*		
	Risk Management	High Interaction	*2.3*	*-8.3*	***8.1***	***0.5***		
		Low Interaction	*-3.0*	*-7.1*	***4.7***	***13.3***		
	Permitting	High Interaction			***10.1***	***2.2***		
		Low Interaction			***3.7***	***13.1***		
	Change Management	High Interaction	**-2.2**	**-8.2**				
		Low Interaction	**-0.4**	**-7.0**				
Project Close-out		High Interaction			***8.9***	***2.2***		
		Low Interaction			***5.0***	***16.6***		

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variable is statistically significant at the 0.1 significance level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

On schedule performance, one ordinal interaction has been found at the task interaction for social impact analysis. In addition, five disordinal interactions have been shown at the task interactions for communication, risk management, permitting, and project close-out. Among them, the interactions of involvement of the contract/legal manager and task interactions for risk management, permitting, and project close-out are statistically significant at the 0.1 level. In the task interaction for risk management, the schedule performance of the projects in high/high quadrant is 12.8% better than those in high/low quadrant and it is 7.6% better than those in low/high quadrant. In addition, the task interaction for permitting, the schedule performance of the projects in the high/high quadrant is 10.9% better than those in the high/low quadrant and it is 7.9% better than those in low/high quadrant. Finally, the task interaction for project close-out, the schedule performance of the projects in the high/high quadrant is 14.4% better than those in the high/low quadrant and it is 6.7% better than those in the low/high quadrant. No interaction effect has been found on change performance.

Table 5.19 shows the interaction effects of involvement of the operation/production manager and interaction of the tasks that the operation/production manager is involved in. Three ordinal interactions on cost performance have been found at the task interactions for social impact analysis, QA/QC, and Human Resource Management. In addition, twelve disordinal interactions on cost performance have been found at the task interactions for economic feasibility analysis, environmental impact analysis, procurement strategy, project management, estimating, cost management, risk management contracting, permitting, HSE, claims management, detailed engineering,

construction, and project close-out. Among them, interaction effects of involvement of operation/production manager and task interactions for contracting and permitting are statistically significant at the 0.1 level.

Table 5.19 Results of PI of Operations/Production Manager and TI on Performance (in %)

Task Interaction			Project Cost Growth		Project Schedule Growth		Change Cost Factor	
			Operations/Production Manager		Operations/Production Manager		Operations/Production Manager	
			Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	Economic Feasibility	High Interaction	*-3.2*	*-6.9*				
		Low Interaction	*-3.8*	*0.5*				
	Social Impact Analysis	High Interaction	**-5.9**	**-8.4**	**1.1**	**0.3**		
		Low Interaction	**-0.9**	**-3.9**	**9.1**	**1.9**		
	Environmental Impact Analysis	High Interaction	*-3.2*	*-5.9*				
		Low Interaction	*-3.8*	*-2.0*				
	Procurement Strategy	High Interaction	*-3.6*	*-6.0*				
		Low Interaction	*-3.2*	*-0.4*				
Project Execution	Project Management	High Interaction	*-2.5*	*-5.7*				
		Low Interaction	*-4.3*	*0.8*				
	Estimating	High Interaction	*-4.5*	*-5.6*				
		Low Interaction	*-2.7*	*-0.2*				
	Cost Management	High Interaction	*-3.0*	*-4.0*				
		Low Interaction	*-3.6*	*-2.5*				
	Risk Management	High Interaction	*0.4*	*-5.3*	*8.3*	*1.4*		
		Low Interaction	*-4.1*	*-4.0*	*4.9*	*9.7*		

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variable is statistically significant at the 0.1 significance level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 5.19 Results of PI of Operations/Production Manager and TI on Performance (in %) (Continued)

Task Interaction			Project Cost Growth		Project Schedule Growth		Change Cost Factor	
			Operations/Production Manager		Operations/Production Manager		Operations/Production Manager	
			Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Project Execution	Contracting	High Interaction	***-2.2***	***-6.0***				
		Low Interaction	***-5.3***	***2.3***				
	Permitting	High Interaction	***2.1***	***-5.9***				
		Low Interaction	***-5.8***	***-0.4***				
	Funding Requests	High Interaction			*3.9*	*3.3*		
		Low Interaction			*7.8*	*10.5*		
	HSE	High Interaction	*-4.0*	*-7.1*				
		Low Interaction	*-1.3*	*1.1*				
	Claims Management	High Interaction	*-0.8*	*-5.9*	*8.5*	*4.1*		
		Low Interaction	*-3.5*	*-3.7*	*5.6*	*7.8*		
	QA/QC	High Interaction	**-3.9**	**-4.0**				
		Low Interaction	**-2.7**	**-3.7**				
	Human Resource Management	High Interaction	**-2.5**	**-5.8**	*4.2*	*0.4*		
		Low Interaction	**-2.1**	**-5.7**	*3.5*	*5.6*		
	Detailed Engineering	High Interaction	*-3.2*	*-4.0*				
		Low Interaction	*-3.5*	*-3.0*				
	Construction	High Interaction	*-1.3*	*-5.5*				
		Low Interaction	*-4.1*	*-1.1*				
	Startup /Commissioning	High Interaction			*7.8*	*2.6*		
		Low Interaction			*4.7*	*11.6*		
Project Close-out		High Interaction	*-3.1*	*-4.0*	*9.6*	*3.2*		
		Low Interaction	*-3.5*	*-2.9*	*4.6*	*10.7*		

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variable is statistically significant at the 0.1 significance level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

On schedule performance, one ordinal interaction has been found at the task interaction for social impact analysis. In addition, six disordinal interactions have been shown at the task interactions for risk management, funding requests, claims management, human resource management, startup/commissioning, and project close-out. No interaction effect has been found on change performance.

Table 5.20 shows the interaction effects of involvement of portfolio/program manager and interaction of the tasks that portfolio/program manager is involved in. Two ordinal interactions on cost performance have been found at the task interactions for estimating and change management. In addition, twelve disordinal interactions on cost performance have been found at the task interactions for financial appraisal, technical feasibility analysis, manufacturing objectives criteria, project scope, site information, procurement strategy, cost management, management information system, contracting, funding requests, QA/QC, and detailed engineering. Among them, interaction effects of involvement of operation/production manager and task interactions for project scope, site information, and funding requests are statistically significant at the 0.1 level. In the task interaction for project scope, the cost performance of the projects in the high/high quadrant is 7.8% better than those in the high/low quadrant and it is 5.2% better than those in the low/high quadrant. In addition, in the task interaction for site information, the cost performance of the projects in the high/high quadrant is 7.4% better than those in the high/low quadrant and it is 6.3% better than those in the low/high quadrant.

Table 5.20 Results of PI of Portfolio/Program Manager and TI on Performance (in %)

Task Interaction			Project Cost Growth		Project Schedule Growth		Change Cost Factor	
			Portfolio/Program Manager		Portfolio/Program Manager		Portfolio/Program Manager	
			Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	Financial Feasibility	High Interaction	*-3.6*	*-8.7*			*2.8*	*1.4*
		Low Interaction	*-5.4*	*-1.5*			*2.8*	*2.7*
	Technical Feasibility	High Interaction	*-3.5*	*-4.0*			*3.1*	*1.3*
		Low Interaction	*-3.9*	*-3.5*			*2.0*	*3.3*
	Manufacturing Objectives Criteria	High Interaction	*-1.6*	*-5.2*			*1.8*	*1.7*
		Low Interaction	*-5.1*	*1.3*			*2.9*	*3.1*
	Business Objectives	High Interaction					*2.2*	*1.5*
		Low Interaction					*2.9*	*4.1*
	Project Scope	High Interaction	***-1.4***	***-6.6***			*1.7*	*1.4*
		Low Interaction	***-6.2***	***1.2***			*3.3*	*4.5*
	Site Information	High Interaction	***-2.2***	***-8.5***			C.T.	
		Low Interaction	***-6.7***	***-1.1***				
	Procurement Strategy	High Interaction	*-4.5*	*-6.4*	*8.7*	*1.1*	*2.7*	*0.6*
		Low Interaction	*-2.1*	*-1.5*	*6.1*	*3.5*	*2.3*	*3.1*
Project Execution	Estimating	High Interaction	**-4.6**	**-8.5**	C.T.		C.T.	
		Low Interaction	**-1.5**	**-1.8**				
	Cost Management	High Interaction	*-3.2*	*-5.8*	*8.9*	*1.1*	C.T.	
		Low Interaction	*-5.1*	*-2.2*	*4.6*	*3.2*		
	Scheduling	High Interaction			**4.9**	**-0.2**	**2.3**	**2.1**
		Low Interaction			**12.7**	**6.7**	**3.4**	**2.4**
	Management Information System	High Interaction	*-4.9*	*-6.9*	**6.5**	**1.7**	*2.7*	*1.5*
		Low Interaction	*-2.3*	*0.4*	**9.5**	**3.7**	*2.4*	*3.0*

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variable is statistically significant at the 0.1 significance level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 5.20 Results of PI of Portfolio/Program Manager and TI on Performance (in %) (Continued)

Task Interaction			Project Cost Growth		Project Schedule Growth		Change Cost Factor	
			Portfolio/Program Manager		Portfolio/Program Manager		Portfolio/Program Manager	
			Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Project Execution	Risk Management	High Interaction					**2.5**	**1.6**
		Low Interaction					**3.0**	**2.5**
	Contracting	High Interaction	*-2.3*	*-5.2*	*13.4*	*-0.8*	C.T.	
		Low Interaction	*-5.2*	*-1.5*	*4.1*	*4.1*		
	Funding Requests	High Interaction	***-4.0***	***-8.7***	**4.2**	**2.3**	*2.2*	*1.5*
		Low Interaction	***-3.3***	***6.5***	**12.0**	**3.2**	*3.1*	*4.1*
	Change Management	High Interaction	**-4.4**	**-5.8**	**6.2**	**1.1**	C.T.	
		Low Interaction	**-1.8**	**-2.2**	**11.1**	**3.2**		
	HSE	High Interaction					*2.6*	*1.3*
		Low Interaction					*2.5*	*3.8*
	Claims Management	High Interaction					***2.7***	***0.5***
		Low Interaction					***2.4***	***4.2***
	QA/QC	High Interaction	*-3.0*	*-8.9*	C.T.		C.T.	
		Low Interaction	*-5.4*	*-2.0*				
	Detailed Engineering	High Interaction	*-3.5*	*-4.8*	C.T.		C.T	
		Low Interaction	*-4.6*	*-2.8*				
	Startup /Commissioning	High Interaction					**2.5**	**1.8**
		Low Interaction					**2.7**	**2.4**

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variable is statistically significant at the 0.1 significance level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

On schedule performance, four ordinal interactions have been found at the task interactions for scheduling, management information system, funding requests, and

change management. In addition, three disordinal interactions have been shown at the task interactions for procurement strategy, cost management, and contracting.

On change performance, three ordinal interactions have been found at the task interactions for scheduling, risk management, and startup/commissioning. In addition, ten disordinal interactions have been shown at the task interactions for financial appraisal, technical feasibility analysis, manufacturing objectives criteria, business objectives, project scope, procurement strategy, management information system, funding requests, HSE, and claims management. Among them, interaction effects from involvement of the portfolio/program manager and task interaction for claims management is statistically significant at the 0.1 level. In the task interaction for claims management, the change performance of the projects in high/high quadrant is 3.7% better than those in high/low quadrant and it is 2.2% better than those in low/high quadrant.

5.5 DISCUSSIONS

This chapter tests the second research question, “Does the business-project interface affect project performance outcomes?” To accomplish this, the chapter investigates the relationships of personnel involvement and task interaction, as well as the interaction effects of personnel involvement and task interaction on major performance metrics. Three main propositions developed in this chapter provide the individual and synergistic impacts of the business-project interface on performance outcomes. The first proposition suggests the individual impacts on performance outcomes in terms of the involvement of key management personnel and the second examines task-level

interaction between business and project units for major work functions throughout development of a capital project. The third proposition proposes that there are synergistic benefits from key personnel's involvement and task-based interaction in certain work functions.

Table 5.21 summarizes the propositions and findings of research question two. The relationships between the owner's personnel involvement and performance outcomes, as stated in Proposition 2-1, were partially supported by the findings. Greater involvement by most management personnel were found to have positive associations with cost, schedule, change, and business performance, but the most statistically significant results were found in the relationships between project unit personnel and performance. Only a few statistically significant results were found in the limited relationships between business unit personnel and performance, particularly the business unit manager, project sponsor, finance manager, facility/plant manager, and operations/production manager.

Proposition 2-2, which asserts the relationships between task interaction and performance outcomes were also partially supported by the findings, as show in Table 5.21. Positive relationships between task interaction and performance were shown in limited work functions related with project definition, funding, and control. In addition, most statistically significant results were found in the relationships between those work functions and cost and change performance.

Building from the findings of the previous two propositions, Proposition 2-3 states that there are interaction effects that arise from personnel involvement and task

interaction on performance outcomes. It is necessary to take into account these two elements synthetically in order to investigate and understand the business-project interface. Proposition 2-3 is supported by the findings, as shown in Table 5.21. When personnel involvement and task interaction were taken into account concurrently, numerous meaningful interactions were found. Some limited interactions had statistically significant results at the 0.1 significance level. It seems likely that more statistically significant results will be found once more data are obtained. Nevertheless, these findings support the assertion that increased business-project alignments lead to improved performance outcomes. Significant task interactions provide managerial focus, and require business unit personnel to interact with the project unit. The findings summarized in Table 5.21 show the synergy effects of personnel involvement and task interaction on performance outcomes like a block-and-tackle system. In essence, management interaction with project personnel leverages and magnifies the positive effects of management attention to critical tasks.

Table 5.21 Summary of Propositions and Findings for Research Question Two

Proposition 2-1: The more the owner's management personnel interface with a capital project, the better the performance outcome.

Findings:

- Most involvements of owner's management personnel show positive association with cost, schedule, change, and business performance but some personnel involvements show statistically significant association with performance outcomes.
- No statistically significant association has been found between personnel involvement and cost performance.
- The schedule performance has statistically significant associations with the involvement of finance manager, project controls manager, engineering team lead, and QA/QC manager.
  - In the $5MM-$50MM cost category, the involvements of accounting manager and HSE manager also shows statistically significant association with schedule performance.
  - In the >$50MM cost category, only project sponsor's involvement shows statistically significant correlation with schedule performance.
- The change performance has statistically significant associations with the involvement of business unit manager, project sponsor, and facility/plant manager.
  - On the other hand, no statistically significant association has been found in each cost category.
- The business performance shows statistically significant associations with the involvements of project sponsor, facility/plant manager, operations/production manager, engineering team lead, and procurement manager in all project data.
  - In the $5MM-$50MM cost category, the involvements of finance manager, facility/plant manager, engineering manager, and engineering team lead show statistically significant correlations with business performance.
  - In the >50MM cost category, there is no statistically significant association between personnel involvement and business performance.

Proposition 2-2: The more the project unit personnel interact with business unit personnel for work functions during the development of a capital project, the better the performance outcomes.

Findings:

- Positive associations between task-based interaction and performance outcomes are shown in the limited work functions related to project definition, funding, and risk management, and most statistically significant associations has been found in cost and change performance.
- For all project data, cost performance has positive associations with financial appraisal, manufacturing objectives criteria, business objectives, project scope among planning tasks as well as project management, funding requests, and HSE among

execution tasks, and these associations are statistically significant.
  - In the $5MM-$50MM cost category, the task-based interaction of two execution tasks such as project management and HSE have statistically significant associations with cost performance.
  - In the >$50MM cost category, only one task-based interaction for financial appraisal is statistically significantly associated with cost performance.
- In the $5MM-$50MM cost category, schedule performance shows positive and statistically significant associations with only three task-based interactions for priority setting, risk management, and startup/commissioning.
- Only for all project data, change performance has positive and statistically significant association with the task-based interaction for strategic planning, project scope, procurement strategy, project management, accounting, scheduling, communication, risk management, and HSE.
- Only one task-based interaction for funding requests is positive associated with business performance and is statistically significant.

Proposition 2-3: Projects with high involvement of business unit personnel and high interaction between business and project unit have better performance outcomes.

Findings:

- Projects with high involvement of project sponsor and high interactions between business and project unit for the following work functions show improved cost and schedule performance:
  - Cost performance: financial appraisal, economic feasibility, social impact, and environmental impact, value engineering, procurement strategy, estimating, cost management, change management, detailed engineering, and project close-out
  - Schedule performance: project close-out
  - Among them, the interaction effects of high involvement of project sponsor and high interaction for project close-out on both cost and schedule performance are statistically significant.
- Projects with high involvement of accounting manager and high interactions between business and project unit for the following work functions show improved cost and schedule performance:
  - Cost performance: financial appraisal, economic feasibility, procurement strategy, project management, and project close-out
  - Schedule performance: funding requests, and project close-out
  - Among them, the interaction effects of high involvement of accounting manager and high interaction for project close-out on schedule performance is statistically significant.
- Projects with high involvement of finance manager and high interactions between business and project unit for the following work functions show improved cost, schedule, and change performance:
  - Cost performance: financial appraisal, procurement strategy, funding requests,

and project close-out.
  - Schedule performance: financial appraisal, procurement strategy, funding requests, and project close-out.
  - Change performance: financial appraisal, and business objectives
  - Among them, no statistically significant interaction has been found.
- Projects with high involvement of information technology manager and high interactions between business and project unit for the following work functions show improved cost and change performance:
  - Cost performance: management information system
  - Change performance: project scope, and project execution plan
  - Among them, the interaction effects of high involvement of information technology manager and high interaction for project execution plan on change performance is statistically significant.
- Projects with high involvement of facility/plant manager and high interactions between business and project unit for the following work functions show improved cost, schedule, and change performance:
  - Cost performance: value engineering, site information, and procurement strategy, estimating, cost management, scheduling, change management, QA/QC, detailed engineering, construction, and project close-out
  - Schedule performance: scheduling, funding requests, construction, startup/commissioning, and project close-out
  - Change performance: manufacturing objectives criteria, business objectives, project scope, site information, project execution plan, scheduling, communication, detailed engineering, and startup/commissioning
  - Among them, the interaction effects of high involvement of facility/plant manager and high interaction for construction and project close-out on schedule performance are statistically significant.
- Projects with high involvement of contract/legal manager and high interactions between business and project unit for the following work functions show improved cost and schedule performance:
  - Cost performance: social impact analysis, environmental impact analysis, communication, risk management, and change management
  - Schedule performance: social impact analysis, communication, risk management, permitting, project close-out
  - Among them, the interaction effects of high involvement of contract/legal manager and high interaction for risk management, permitting, and project close-out on schedule performance are statistically significant.
- Projects with high involvement of operations/production manager and high interactions between business and project unit for the following work functions show improved cost and schedule performance:
  - Cost performance: economic feasibility, social impact analysis, environmental impact analysis, procurement strategy, project management, estimating, cost management, risk management, contracting, permitting, HSE, claims

management, QA/QC, human resource management, detailed engineering, construction, and project close-out
- Schedule performance: social impact analysis, risk management, funding requests, claims management, human resource management, startup/commissioning, and project close-out
- Among them, the interaction effects of high involvement of operations/production manager and high interaction for contracting and permitting on cost performance are statistically significant.

- Projects with high involvement of portfolio/program manager and high interactions between business and project unit for the following work functions show improved cost and schedule performance:
  - Cost performance: financial appraisal, technical feasibility, manufacturing objectives criteria, project scope, site information, procurement strategy, estimating, cost management, management information system, contracting, funding requests, change management, QA/QC, and detailed engineering
  - Schedule performance: procurement strategy, cost management, scheduling, management information system, contracting, funding requests, and change management
  - Change performance: financial appraisal, technical feasibility, manufacturing objectives criteria, business objectives, project scope, procurement strategy, scheduling, management information system, risk management, funding requests, HSE, claims management, and startup/commissioning
  - Among them, the interaction effects of high involvement of portfolio/program manager and high interaction for project scope and site information, and funding requests on cost performance are statistically significant.
  - In addition, the interaction effect of high involvement of portfolio/program manager and high task-based interaction for claims management on change performance is statistically significant.

CHAPTER 6: BUSINESS-PROJECT INTERFACE ENHANCING VALUE OF BEST PRACTICES

6.1 BACKGROUND

This chapter presents the impacts of personnel involvement as an enhancer for improving the value of best practices in a capital project. The chapter confirms the third research question, "Does the business-project interface enhance the value of best practices? Two types of analyses have been accomplished to examine the relationships of personnel involvement and the implementation levels of best practices and their interaction effects on performance outcomes.

6.2 PROPOSITIONS

Best practices implementation often requires strong support and commitment from business executives or functional professionals to be successful. The CII Implementation Strategy Committee defines the roles of executive support for successful implementation of best practices as beginning at the top level of the implementation support structure and working down through the organization (CII 2012). The committee suggested the roles for successful implementation of best practices in terms of senior executive support, an executive champion, implementation champion(s), and implementation analyst(s). Among them, senior executive support is one of the critical roles for successful implementation of best practices. The vision for engaging in a best practice implementation needs to be communicated by individuals in a senior

management position which lie not in the title, but rather in the ability to set an enforcement policy across the organization. In addition, the committee pointed out that it is management support is necessary to provide resources as well as management commitment to succeed. An individual in an upper management role must be assigned the responsibility of overseeing and championing implementation efforts from the management perspective. This individual is critical to the success of the process as they often control the budget, personnel, and communications links required to promote, fosters, and deliver implementation efforts. In addition, it was noted that the organization needs to appoint several subject area experts as implementation champions who can oversee the implementation efforts related to their respective areas of expertise (CII 2012). Thus, it is reasonably presumed that the involvement of the owner's management personnel is required to better implement best practices. Based on the above statements, the first research proposition is addressed as follow:

Proposition 3-1: The more the owner's management personnel interface with a capital project, the better the implementation of best practices.

The relationships between the implementation level of best practices and performance have been well studied in previous CII studies (CII 2003b; CII 2010; Suk 2012). The CII Value of Best Practices Reports (2010) clearly demonstrated that high use of best practices provides significant benefits for both owners and contractors in terms of cost and schedule performance. Specifically, the cost performance in the projects with high use of best practices is 10.9% better than those with low use at the 0.05 significance level. Schedule performance in projects with high use of best practices is 9.7% better than

those of low use at the 0.1 significance level. In addition, the high use of planning-related best practices leads to better cost performance. Projects with high use of CII Planning Best Practices have 7.5% better cost performance compared to those with low use (CII 2010). From the findings of the existing CII studies, the second proposition is presumed as follow:

Proposition 3-2: The more the implementation of best practices, the better the performance outcomes.

The previous propositions presume that personnel involvement facilitates better implementation of best practices and best practices would contribute to better performance outcomes. Based on the above statements, the third research proposition is addressed as follows:

Proposition 3-3: Projects with high involvement of owner's management personnel and high implementation of best practices have better performance outcomes.

Based on the proposed research propositions, this research examines not only the direct effects of personnel involvement on best practices implementation but also interaction effects on performance outcomes through combining personnel involvement and best practices as intervening variables between personnel involvement and performance outcomes. The following section explains data preparation and analysis procedures used to answer those research propositions linked with the third research question.

6.3 SIMPLE CORRELATION

Associations between personnel involvement and best practices were investigated in a similar fashion as the analysis on relationships between personnel involvement and task interaction described in the previous chapter. This research used contingency table analysis to determine the optimal level which maximizes the relationship between personnel involvement and best practice implementation.

Among the two dichotomous variables, the categories of the dependent variables are determined based on the given criteria as shown in Table 6.1. As stated in Chapter 3, best practice scores are designed with an interval level of measurement, and their scores are calculated through a calculation algorithm developed by the CII BM&M committee members. The best practice scores are transformed based on the criteria of "Above Median" and "Below Median" as shown in Table 6.1. For best practice scores, larger value indicates better implementation.

Table 6.1 Categories of Best Practice Scores

Best Practices	Original Level of Measurement	Transferred Level of Measurement	
		High Use Criterion	Low Use Criterion
Front End Planning	Interval	Above Median	Below Median
Alignment during FEP	Interval	Above Median	Below Median
Partnering	Interval	Above Median	Below Median
Team Building	Interval	Above Median	Below Median
Project Delivery & Contract Strategy	Interval	Above Median	Below Median
Constructability	Interval	Above Median	Below Median
Project Risk Assessment	Interval	Above Median	Below Median
Change Management	Interval	Above Median	Below Median
Zero Accident Technique	Interval	Above Median	Below Median
Planning for Startup	Interval	Above Median	Below Median

The categories of independent variables are determined by contingency table analysis when the level of association between two dichotomous variables is maximized, as shown in Table 6.2. The phi coefficient is also used for the measure of association which can be applied to two dichotomous variables. The phi coefficient in the contingency table analysis and test of significance will be explained in the following section. The samples used in this analysis are relatively small size (27 or less).

Table 6.2 Contingency Table for Relationship between PI and Best Practice

		Best Practice		Total
		Low Use	High Use	
Level of Involvement	High Involvement (>= *k*)	*a*	*b*	*a*+*b*
	Low Involvement (< *k*)	*c*	*d*	*c*+*d*
Total		*a*+*c*	*b*+*d*	*a*+*b*+*c*+*d*

6.3.1 Relationships between Personnel Involvement and Best Practices

This section describes the relationship between personnel involvement and the level of best practice implementation using the phi coefficient (ϕ). The relationships are also provided for two cost categories, $5MM-$50MM, and > $50MM. Projects with a cost category of <$5MM are not included because the sample number is less than 10. All associations are examined at the 0.1 significance level.

Table 6.3 Phi Coefficient between PI and Front End Planning

Management Personnel		Front End Planning		
			Cost Category	
		All	$5MM - $50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	0.012	-0.250	0.333
	Business Unit Manager	-0.355	-0.419	-0.408
	Project Sponsor	0.316	0.378	0.500
Functional Management Personnel	Accounting Manager	0.307	0.491	0.333
	Finance Manager	*0.387	*0.764	0.639
	Marketing/Sales Manager	N.A	N.A	N.A
	Human Resource Manager	0.236	0.286	0.218
	Information Technology Manager	0.292	*0.535	0.408
	Facility/Plant Manager	*0.368	*0.764	0.333
	Contract & Legal Manager	0.277	0.464	0.000
	Operations/ Production Manager	0.307	0.286	0.333
	Portfolio/Program Manager	0.236	0.419	0.000
Project Management Personnel	Project Manager	N.A	N.A	N.A
	Project Controls Manager	*0.359	0.472	0.218
	Engineering Manager	*0.397	*0.607	0.408
	Engineering Team Lead	*0.359	0.472	0.218
	Procurement Manager	*0.384	0.491	0.500
	Construction Manager	0.080	0.094	N.A
	QA/QC Manager	*0.368	0.472	0.333
	HSE Manager	0.113	0.327	-0.218

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 10 to 25
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

Table 6.3 shows that most associations between personnel involvement and front end planning are positively associated. Among the business unit personnel, when the Finance Manager and Facility/Plant Manager are more involved in a project, the Front End Planning is better implemented. On the other hand, the Project Controls Manager, Engineering Manager, Engineering Team Lead, Procurement Manager, and QA/QC Manager contributed to better implementation of Front End Planning. Particularly in the $5MM-$50MM cost category, when the Finance Manager, Information Technology

Manager, and Engineering Manager spend more of their time on a project, Front End Planning is better implemented.

Table 6.4 Phi Coefficient between PI and Alignment during FEP

Management Personnel		Alignment during FEP		
			Cost Category	
		All	$5MM - $50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	-0.105	-0.250	0.000
	Business Unit Manager	-0.189	-0.419	-0.169
	Project Sponsor	0.301	0.378	0.192
Functional Management Personnel	Accounting Manager	0.265	0.491	0.000
	Finance Manager	*0.367	*0.764	0.302
	Marketing/Sales Manager	N.A	N.A	N.A
	Human Resource Manager	0.113	0.286	0.000
	Information Technology Manager	0.204	*0.535	0.302
	Facility/Plant Manager	*0.346	*0.764	0.000
	Contract & Legal Manager	0.331	0.464	0.169
	Operations/ Production Manager	0.052	0.286	0.302
	Portfolio/Program Manager	0.204	0.419	-0.192
Project Management Personnel	Project Manager	N.A	N.A	N.A
	Project Controls Manager	**0.407	0.472	0.354
	Engineering Manager	0.301	*0.607	0.169
	Engineering Team Lead	*0.335	0.472	0.192
	Procurement Manager	0.301	0.491	0.192
	Construction Manager	0.078	0.094	N.A
	QA/QC Manager	**0.419	0.472	0.354
	HSE Manager	0.262	0.327	0.192

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 12 to 27
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

As can be seen in Table 6.4, most associations between personnel involvement and Alignment during Front End Planning show positive associations, indicating that the more the management personnel are involved in a project, the better the best practice is

implemented. Alignment during Front End Planning is better implemented when the Finance Manager, Facility/Plant Manager, Project Controls Manager, Engineering Team Lead, and QA/QC Manager spend more time on a project. Particularly in the $5MM-$50MM cost category, when the Finance Manager, Information Technology Manager, and Engineering Manager spend more their time for a project, Front End Planning is better implemented.

As can be seen in Table 6.5, most personnel involvement have positively associations with Partnering, indicating that the more the management personnel are involved in a project, the better the Partnering practice is implemented. Among the business unit personnel, the Project Sponsor, Finance Manager, Information Technology Manager, and Facility/Plant Manager significantly contributed to better implementation of Partnering at the 0.1 significance level. Indeed, the implementation level of Partnering is affected by most project management personnel.

Particularly in the $5MM-$50MM cost category, more personnel involvement was found to have significant association with Partnering. Among business unit personnel, the Project Sponsor, Accounting Manager, Finance Manager, Facility/Plant Manager, and Contract/Legal Manager contributed better Partnering implementation. The involvement of most project management personnel are significant, as associated with Partnering, including the Project Controls Manager, Engineering Manager, Engineering Team Lead, Procurement Manager, and QA/QC Manager

Table 6.5 Phi Coefficient between PI and Partnering

Management Personnel		Partnering		
			Cost Category	
		All	$5MM - $50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	0.209	N.A	0.239
	Business Unit Manager	-0.275	-0.337	0.069
	Project Sponsor	*0.354	*0.625	-0.039
Functional Management Personnel	Accounting Manager	0.333	*0.732	-0.069
	Finance Manager	**0.430	*0.732	-0.039
	Marketing/Sales Manager	N.A	N.A	N.A
	Human Resource Manager	0.224	0.365	0.039
	Information Technology Manager	*0.385	0.539	0.214
	Facility/Plant Manager	*0.385	*0.625	0.134
	Contract & Legal Manager	0.251	*0.732	-0.214
	Operations/ Production Manager	0.177	0.433	0.069
	Portfolio/Program Manager	0.224	0.365	0.039
Project Management Personnel	Project Manager	N.A	N.A	N.A
	Project Controls Manager	**0.458	*0.732	-0.039
	Engineering Manager	**0.458	*0.732	-0.069
	Engineering Team Lead	**0.418	*0.675	-0.039
	Procurement Manager	**0.458	*0.625	0.134
	Construction Manager	*0.378	0.433	N.A
	QA/QC Manager	**0.430	*0.732	-0.039
	HSE Manager	*0.378	0.537	-0.386

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 11 to 24
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

As can be seen in Table 6.6, Team Building is better implemented when functional management such as the finance manager, human resource manager, information technology manager, facility/plant manager, operations/production manager, and portfolio/program manager personnel interface more with a capital project. In addition, the Engineering Manager and Procurement Manager also significantly

contributed to better Team Building at the 0.1 significance level. Particularly, in the >$50MM cost category, a statistically significant association exists between Team Building and functional managers, including the Human Resource Manager and Information Technology Manager, Operations/Production Manager, and Portfolio/Program Manager.

Table 6.6 Phi Coefficient between PI and Team Building

Management Personnel		Team Building		
		All	Cost Category	
			$5MM - $50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	0.327	N.A	0.357
	Business Unit Manager	0.327	0.182	0.357
	Project Sponsor	0.237	0.337	0.293
Functional Management Personnel	Accounting Manager	0.318	0.395	0.529
	Finance Manager	**0.428	0.337	0.488
	Marketing/Sales Manager	N.A	N.A	N.A
	Human Resource Manager	*0.457	-0.123	*0.683
	Information Technology Manager	**0.527	0.272	*0.657
	Facility/Plant Manager	**0.473	0.284	0.529
	Contract & Legal Manager	0.127	-0.033	0.255
	Operations/ Production Manager	**0.457	-0.123	*0.683
	Portfolio/Program Manager	**0.700	0.677	*0.683
Project Management Personnel	Project Manager	N.A	N.A	N.A
	Project Controls Manager	0.190	0.101	0.255
	Engineering Manager	*0.405	0.409	0.314
	Engineering Team Lead	0.194	0.101	0.255
	Procurement Manager	*0.350	0.284	0.378
	Construction Manager	0.029	-0.178	N.A
	QA/QC Manager	0.097	0.182	0.098
	HSE Manager	-0.044	0.033	-0.098

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 12 to 25
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

As shown in Table 6.7, statistically significant associations exist between the Project Delivery & Contract Strategy (PDCS) and Accounting Manager, the Finance Manager, Project Controls Manager, and Engineering Manger. Most associations between personnel involvement and PDCS are positive, particularly for the Business Unit Manager, Project Sponsor, and Contract/Legal Manager who may have key personnel for PDCS implementation. However, no statistically significant association has been found among them.

Table 6.7 Phi Coefficient between PI and PDCS

Management Personnel		Team Building		
			Cost Category	
		All	$5MM - $50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	-0.218	N.A	-0.333
	Business Unit Manager	0.293	0.447	0.200
	Project Sponsor	0.293	0.507	0.000
Functional Management Personnel	Accounting Manager	*0.378	0.507	0.218
	Finance Manager	**0.455	0.507	0.408
	Marketing/Sales Manager	N.A	N.A	N.A
	Human Resource Manager	-0.316	-0.302	-0.333
	Information Technology Manager	-0.218	-0.354	-0.218
	Facility/Plant Manager	0.204	0.354	0.000
	Contract & Legal Manager	0.273	0.507	0.333
	Operations/ Production Manager	0.000	0.192	-0.408
	Portfolio/Program Manager	-0.316	-0.302	-0.500
Project Management Personnel	Project Manager	N.A	N.A	N.A
	Project Controls Manager	*0.408	0.507	0.333
	Engineering Manager	*0.408	0.507	0.333
	Engineering Team Lead	0.325	0.507	0.333
	Procurement Manager	0.204	0.354	0.000
	Construction Manager	0.132	0.192	N.A
	QA/QC Manager	0.277	0.507	0.000
	HSE Manager	0.277	0.333	0.218

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 10 to 22
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

Table 6.8 presents the association between personnel involvement and implementation of Constructability. Most associations are positive, indicating that the more the personnel involvement, the better the implementation of Constructability. The involvements of the Project Sponsor and Information Technology Manager have statistically significant association with better implementation of Constructability. Particularly, in the $5MM-$50MM cost category, the Information Technology Manager significantly contributes to better implementation of Constructability.

Table 6.8 Phi Coefficient between PI and Constructability

Management Personnel		Constructability		
			Cost Category	
		All	$5MM - $50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	0.209	N.A	0.346
	Business Unit Manager	0.209	0.267	-0.267
	Project Sponsor	*0.378	0.267	0.559
Functional Management Personnel	Accounting Manager	0.302	0.267	0.346
	Finance Manager	0.302	0.267	0.467
	Marketing/Sales Manager	N.A	N.A	N.A
	Human Resource Manager	0.224	0.267	0.261
	Information Technology Manager	**0.500	*0.732	0.346
	Facility/Plant Manager	0.209	0.051	0.430
	Contract & Legal Manager	-0.209	-0.548	0.069
	Operations/ Production Manager	0.126	0.267	0.289
	Portfolio/Program Manager	0.209	0.395	-0.149
Project Management Personnel	Project Manager	N.A	N.A	N.A
	Project Controls Manager	-0.084	-0.238	0.559
	Engineering Manager	0.275	0.395	0.289
	Engineering Team Lead	0.092	-0.098	0.559
	Procurement Manager	0.224	0.267	0.430
	Construction Manager	-0.378	-0.507	N.A
	QA/QC Manager	0.086	-0.238	0.559
	HSE Manager	-0.086	-0.267	0.261

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 11 to 24
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

All business and project unit roles significantly contributed to better implementation of Project Risk Assessment, as shown in Table 6.9, except for the CEO,

Business Unit Manager, and Construction Manager. The phi coefficient for the Marketing Manager and Project Manager could not be calculated because their level of involvement was constant in the data set. In the $5MM-$50MM cost category, the involvements of the Project Sponsor, Accounting Manager, Finance Manager, Information Technology Manager, Facility/Plant Manager, Engineering Manager, and Procurement Manager have statistically significant associations with the implementation of Project Risk Assessment. In the >$50MM cost category, the Finance Manager and Facility/Plant Manager significantly contributed to better Project Risk Assessment.

Table 6.9 Phi Coefficient between PI and Project Risk Assessment

Management Personnel		Project Risk Assessment		
			Cost Category	
		All	$5MM - $50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	-0.204	N.A	-0.346
	Business Unit Manager	-0.204	-0.255	-0.100
	Project Sponsor	**0.516	*0.714	0.261
Functional Management Personnel	Accounting Manager	**0.652	*0.845	0.559
	Finance Manager	**0.699	*0.714	*0.671
	Marketing/Sales Manager	N.A	N.A	N.A
	Human Resource Manager	*0.405	0.357	0.430
	Information Technology Manager	0.313	*0.683	0.289
	Facility/Plant Manager	**0.589	*0.598	*0.633
	Contract & Legal Manager	*0.389	0.507	0.346
	Operations/ Production Manager	*0.405	0.357	0.430
	Portfolio/Program Manager	**0.550	0.529	0.559
Project Management Personnel	Project Manager	N.A	N.A	N.A
	Project Controls Manager	**0.444	0.507	0.346
	Engineering Manager	**0.569	*0.714	0.346
	Engineering Team Lead	*0.394	0.478	0.346
	Procurement Manager	**0.569	*0.598	0.516
	Construction Manager	0.112	0.098	N.A
	QA/QC Manager	**0.411	0.507	0.311
	HSE Manager	*0.397	0.314	0.559

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 11 to 23
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

A few significant associations between personnel involvement and Change Management have been found, as shown in Table 6.10. The involvement of the Finance Manager is significantly associated with Change Management. The Information Technology Manager significantly contributed to better Change Management in the $5MM-$50MM cost category.

Table 6.10 Phi Coefficient between PI and Change Management

Management Personnel		Change Management		
		All	Cost Category	
			$5MM - $50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	-0.209	N.A	-0.346
	Business Unit Manager	-0.209	-0.267	-0.100
	Project Sponsor	0.177	0.312	0.261
Functional Management Personnel	Accounting Manager	0.000	0.312	0.149
	Finance Manager	*0.354	0.415	0.267
	Marketing/Sales Manager	N.A	N.A	N.A
	Human Resource Manager	-0.126	0.312	-0.516
	Information Technology Manager	0.167	*0.592	-0.311
	Facility/Plant Manager	0.192	0.283	0.043
	Contract & Legal Manager	0.209	-0.071	0.346
	Operations/ Production Manager	0.126	0.312	0.346
	Portfolio/Program Manager	0.209	0.461	-0.261
Project Management Personnel	Project Manager	N.A	N.A	N.A
	Project Controls Manager	0.084	-0.071	0.261
	Engineering Manager	0.275	0.461	0.100
	Engineering Team Lead	0.092	0.098	0.261
	Procurement Manager	0.192	0.312	0.043
	Construction Manager	-0.126	-0.225	N.A
	QA/QC Manager	0.258	0.238	0.346
	HSE Manager	0.086	0.071	0.149

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 11 to 24
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

As shown Table 6.11, Zero Accident Techniques are significantly associated with the involvement of the Information Technology Manager at the 0.1 significance level. Except for this relationship, no significant association has been found.

Table 6.11 Phi Coefficient between PI and Zero Accident Techniques

Management Personnel		Zero Accident Techniques		
			Cost Category	
		All	$5MM - $50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	0.302	N.A	0.289
	Business Unit Manager	0.209	-0.178	0.289
	Project Sponsor	0.000	-0.158	-0.083
Functional Management Personnel	Accounting Manager	-0.126	-0.051	-0.241
	Finance Manager	-0.086	0.184	-0.463
	Marketing/Sales Manager	N.A	N.A	N.A
	Human Resource Manager	0.103	-0.192	0.039
	Information Technology Manager	**0.418	0.501	0.261
	Facility/Plant Manager	0.126	0.083	-0.083
	Contract & Legal Manager	-0.302	-0.386	-0.289
	Operations/ Production Manager	0.000	-0.192	-0.083
	Portfolio/Program Manager	0.224	0.433	-0.083
Project Management Personnel	Project Manager	N.A	N.A	N.A
	Project Controls Manager	-0.092	-0.386	-0.194
	Engineering Manager	0.103	0.178	-0.083
	Engineering Team Lead	0.000	-0.158	-0.194
	Procurement Manager	0.000	-0.192	-0.083
	Construction Manager	-0.126	-0.426	N.A
	QA/QC Manager	-0.224	-0.178	-0.289
	HSE Manager	-0.224	-0.426	-0.194

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 11 to 24
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

As can be seen Table 6.12, most associations between personnel involvement and Planning for Startup are positive, but only the Project Controls Manager's involvement has statistically significant association with Planning for Startup in all data set. On the other hand, the Project Sponsor, Accounting Manager, Contract/Legal Manager, Project Controls Manager, and Engineering Manager significantly contributed to better implementation of Planning for Startup in $5MM-$50MM cost category.

Table 6.12 Phi Coefficient between PI and Planning for Startup

Management Personnel		Planning for Startup		
			Cost Category	
		All	$5MM - $50MM	> $50MM
		Coefficient	Coefficient	Coefficient
Senior Management Personnel	Chief Executive Officer	0.000	N.A	0.000
	Business Unit Manager	0.000	-0.500	0.169
	Project Sponsor	0.293	*0.816	-0.192
Functional Management Personnel	Accounting Manager	0.273	*0.816	-0.169
	Finance Manager	0.183	0.655	-0.169
	Marketing/Sales Manager	N.A	N.A	N.A
	Human Resource Manager	0.000	0.333	-0.192
	Information Technology Manager	0.000	0.500	-0.169
	Facility/Plant Manager	0.325	0.655	0.000
	Contract & Legal Manager	0.273	*0.816	-0.169
	Operations/ Production Manager	0.098	0.500	-0.169
	Portfolio/Program Manager	-0.132	0.333	-0.447
Project Management Personnel	Project Manager	N.A	N.A	N.A
	Project Controls Manager	*0.378	*0.816	0.192
	Engineering Manager	0.325	*0.816	-0.169
	Engineering Team Lead	0.293	0.655	0.000
	Procurement Manager	0.204	0.655	-0.192
	Construction Manager	0.218	0.333	N.A
	QA/QC Manager	0.277	0.655	0.000
	HSE Manager	0.092	0.408	-0.192

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 10 to 24
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

Table 6.13 summarized the optimal level of involvement for management personnel to maximize the relationship with best practice implementation.

Table 6.13 Optimal Level of Management Personnel for Better Best Practices Implementation

Management Personnel		Front End Planning			Alignment during FEP			Partnering			Team Building			Project Delivery & Contract Strategy		
		All	$5M-$50M	>$50M	All	$5M-$50M	>$50M	All	$5M-$50M	>$50M	All	$5M-$50M	>$50M	All	$5M-$50M	>$50M
Senior Management Personnel	Chief Executive Officer	> 0	> 0	> 0	> 0	> 0	> 0	> 0	N.A.	> 0	> 40	N.A.	> 40	> 0	N.A.	> 0
	Business Unit Manager	> 40	> 0	> 0	> 400	> 0	> 0	> 0	> 40	> 0	> 400	> 0	> 40	> 0	> 0	> 0
	Project Sponsor	> 40	> 40	> 400	> 40	> 40	> 40	**> 40**	**> 40**	> 40	> 40	> 40	> 400	> 40	> 40	> 0
Functional Management Personnel	Accounting Manager	> 400	> 0	> 400	> 0	> 0	> 0	> 0	**> 0**	> 0	> 400	> 0	> 400	**> 40**	> 40	> 40
	Finance Manager	**> 0**	**> 0**	> 400	**> 0**	**> 0**	> 400	**> 0**	**> 0**	> 0	**> 0**	> 0	> 0	**> 40**	> 40	> 40
	Marketing/ Sales Manager	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Human Resource Manager	> 0	> 0	> 0	> 0	> 0	> 0	> 0	> 0	> 0	**> 40**	> 0	**> 40**	> 40	> 0	> 40
	Information Technology Manager	> 40	**> 40**	> 0	> 400	**> 40**	> 400	**> 40**	> 40	> 0	**> 40**	> 40	**> 40**	> 400	> 0	> 40
	Facility/Plant Manager	**> 40**	**> 40**	> 400	**> 40**	**> 40**	> 0	**> 0**	**> 40**	> 0	**> 400**	> 0	> 400	> 0	> 0	> 0
	Contract & Legal Manager	> 40	> 40	> 40	> 40	> 40	> 40	> 40	**> 40**	> 40	> 0	> 40	> 0	> 40	> 40	> 0
	Operations/ Production Manager	> 400	> 400	> 0	> 40	> 400	> 0	> 40	> 40	> 40	**> 400**	> 400	**> 400**	> 0	> 40	> 40
	Portfolio/Program Manager	> 0	> 0	> 0	> 400	> 0	> 0	> 0	> 0	> 0	**> 40**	> 40	**> 0**	> 40	> 0	> 0
Project Management Personnel	Project Manager	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Project Controls Manager	**> 400**	> 400	> 400	**> 400**	> 400	> 400	**> 40**	**> 40**	> 400	> 40	> 400	> 40	**> 40**	> 40	> 40
	Engineering Manager	**> 400**	**> 40**	> 400	> 40	**> 40**	> 400	**> 40**	**> 40**	> 400	**> 400**	> 400	> 400	**> 40**	> 40	> 0
	Engineering Team Lead	**> 400**	> 400	> 400	**> 400**	> 400	> 400	**> 400**	**> 400**	> 400	> 400	> 400	> 0	> 0	> 400	> 0
	Procurement Manager	**> 400**	> 40	> 400	> 40	> 40	> 400	**> 40**	**> 40**	> 40	**> 40**	> 40	> 40	> 40	> 40	> 0
	Construction Manager	> 0	> 0	N.A.	> 0	> 0	N.A.	**> 0**	> 0	N.A.	> 400	> 400	N.A.	> 400	> 400	N.A.
	QA/QC Manager	**> 40**	> 400	> 0	**> 400**	> 400	> 400	**> 40**	**> 40**	> 40	> 40	> 0	> 40	> 400	> 400	> 0
	HSE Manager	> 400	> 400	> 400	> 400	> 400	> 400	**> 40**	> 400	> 400	> 40	> 400	> 400	> 400	> 400	> 400

Bold indicates statistically significant association between personnel involvement and performance
Sample size for each correlation range from 10 to 41
N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

Table 6.13 Optimal Level of Management Personnel for Better Best Practices Implementation (Continued)

Management Personnel		Constructability			Project Risk Assessment			Change Management			Zero Accident Techniques			Planning for Startup		
		All	$5M-$50M	>$50M	All	$5M-$50M	>$50M	All	$5M-$50M	>$50M	All	$5M-$50M	>$50M	All	$5M-$50M	>$50M
Senior Management Personnel	Chief Executive Officer	> 0	N.A.	> 0	> 0	N.A.	> 0	> 0	N.A.	> 0	> 0	N.A.	> 0	> 0	N.A.	> 0
	Business Unit Manager	> 40	> 40	> 0	> 40	> 40	> 0	> 40	> 40	> 0	> 400	> 0	> 40	> 40	> 0	> 0
	Project Sponsor	**> 400**	> 400	> 40	**> 40**	**> 40**	> 40	> 40	> 400	> 40	> 0	> 40	> 400	> 40	**> 40**	> 40
Functional Management Personnel	Accounting Manager	> 400	> 400	> 400	**> 0**	**> 0**	> 40	> 0	> 400	> 40	> 400	> 0	> 400	> 0	**> 0**	> 0
	Finance Manager	> 400	> 400	> 40	**> 0**	**> 0**	**> 0**	**> 0**	> 0	> 40	> 0	> 0	> 0	> 40	> 0	> 40
	Marketing/ Sales Manager	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Human Resource Manager	> 0	> 0	> 0	**> 40**	> 0	> 40	> 40	> 0	> 40	> 0	> 0	> 0	> 0	> 0	> 0
	Information Technology Manager	**> 0**	**> 0**	> 400	> 40	**> 40**	> 400	> 0	**> 40**	> 0	**> 0**	> 0	> 0	> 0	> 40	> 0
	Facility/Plant Manager	> 400	> 0	> 0	**> 40**	**> 0**	**> 40**	> 0	> 0	> 0	> 400	> 0	> 400	> 0	> 0	> 0
	Contract & Legal Manager	> 0	> 40	> 40	**> 40**	> 40	> 0	> 0	> 40	> 0	> 0	> 40	> 0	> 40	**> 40**	> 40
	Operations/ Production Manager	> 400	> 400	> 0	**> 400**	> 400	> 400	> 400	> 400	> 0	> 400	> 400	> 400	> 40	> 40	> 40
	Portfolio/Program Manager	> 400	> 0	> 0	**> 0**	> 0	> 0	> 400	> 0	> 0	> 40	> 40	> 0	> 0	> 0	> 0
Project Management Personnel	Project Manager	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Project Controls Manager	> 400	> 40	> 400	**> 40**	> 40	> 40	> 400	> 40	> 400	> 40	> 40	> 40	**> 400**	**> 40**	> 400
	Engineering Manager	> 400	> 400	> 0	**> 40**	**> 40**	> 0	> 400	> 400	> 400	> 0	> 400	> 400	> 40	**> 40**	> 400
	Engineering Team Lead	> 40	> 0	> 400	**> 400**	> 400	> 0	> 40	> 0	> 400	> 0	> 0	> 0	> 400	> 0	> 400
	Procurement Manager	> 400	> 400	> 40	**> 40**	**> 40**	> 40	> 40	> 400	> 40	> 400	> 400	> 400	> 40	> 40	> 40
	Construction Manager	> 0	> 0	N.A.	> 0	> 0	N.A.	> 0	> 0	N.A.	> 0	> 0	N.A.	> 0	> 0	N.A.
	QA/QC Manager	> 40	> 40	> 40	**> 40**	> 40	> 400	> 40	> 40	> 0	> 0	> 0	> 0	> 400	> 40	> 400
	HSE Manager	> 400	> 0	> 400	**> 400**	> 400	> 400	> 400	> 400	> 400	> 40	> 40	> 0	> 400	> 400	> 400

Bold indicates statistically significant association between personnel involvement and performance
Sample size for each correlation range from 10 to 41 N.A. means that the phi coefficient cannot be calculated because the level of involvement data is constant.

6.3.2 Relationships between Best Practices and Performance

Tables 6.14 and 6.15 present the phi coefficients between best practices and performance outcomes for all projects and the $5MM-$50MM cost category. The <$5MM and $5MM-$50MM cost categories did not have enough data to meet the CII confidentiality requirements, so were excluded from this section.

Most of the coefficients are positive, indicating that more use of best practices is associated with better performance, as shown in Table 6.14. The planning best practices such as Front End Planning, Alignment during FEP, and Planning for Startup have positive associations with cost, schedule and business performance. Only associations of Front End Planning and Alignment during FEP with those performance outcomes are statistically significant at the 0.1 significance level, however. Partnering is also positively associated with cost, schedule, and business performance but only cost performance has a significant association with Partnering at the 0.1 significance level.

Table 6.14 Phi Coefficient between BP and Performance (All Projects)

	Performance Outcomes			
Best Practices	Cost	Schedule	Change	Business
Front End Planning	**0.531	**0.691	-0.183	**0.608
Alignment during FEP	**0.507	**0.601	-0.161	**0.621
Partnering	*0.422	0.313	-0.183	0.338
Team Building	-0.122	-0.018	0.231	-0.225
Project Delivery & Contract Strategy	-0.139	0.337	-0.138	0.000
Constructability	0.083	0.098	0.248	0.054
Project Risk Assessment	0.059	0.091	-0.167	0.203
Change Management	0.083	-0.232	0.248	0.054
Zero Accident Techniques	0.103	-0.098	0.017	-0.113
Planning for Startup	0.181	0.355	-0.330	0.408

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 21 to 24

In the cost category of $5MM-$50MM, most of the associations between best practices and performance are positive, indicating that more use of best practices is associated with better performance, as can be seen Table 6.15. The planning best practices such as Front End Planning, Alignment during FEP, and Planning for Startup are positively associated with cost, schedule, and business performance. Front End Planning and Alignment during FEP have statistically significant associations with schedule and business performance and Planning for Startup is statistically significant with business performance at the 0.1 significance level. Partnering has positive associations with cost, schedule, and business performance but the practice has statistically significant associations with schedule and business performance. Project Delivery & Contract Strategy is positive associated with schedule and business performance but the associations are not statistically significant. In addition, Constructability is positively associated with change performance but this association is not statistically significant.

Table 6.15 Phi Coefficient between BP and Cost Performance ($5MM-$50MM)

	Performance Outcomes			
Best Practices	Cost	Schedule	Change	Business
Front End Planning	0.468	*0.603	-0.344	**0.645
Alignment during FEP	0.468	*0.603	-0.344	**0.645
Partnering	0.433	**0.693	-0.625	*0.625
Team Building	-0.409	-0.174	-0.255	-0.426
Project Delivery & Contract Strategy	0.000	0.577	-0.169	0.354
Constructability	0.033	-0.577	0.507	0.000
Project Risk Assessment	-0.076	0.134	-0.690	0.179
Change Management	-0.033	-0.488	-0.029	-0.120
Zero Accident Techniques	0.284	-0.333	-0.098	0.000
Planning for Startup	0.500	0.655	-0.655	**0.816

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1.
Sample size for each correlation range from 13 to 15

6.4 Interaction Effects of Involvement and Best Practices on Performance

This section presents the interaction effects of personnel involvement and best practice use on performance outcomes. The analysis focuses on the difference in the means of one dependent variable (performance outcome) when there are two independent variables (personnel involvement and best practice use). The independent variables are factors such as personnel involvement and best practices, and the dependent variable are performance outcomes such as cost growth, schedule growth, and change cost factor.

6.4.1 Interaction Effect Analysis

Both personnel involvement and best practice scores which are ordinal measures were categorized into high and low groups based on the median value of personnel involvement and best practices calculated from the project data. Finally, the data were divided into four quadrants: high-high, high-low, low-high, and low-low as shown in Figure 6.1. Quadrants do not have to have an equal number of data points because not all projects have all data for personnel involvement and best practices. Median values are identified based on all projects if they have any personnel involvement and best practices data. Applying the median to a set of projects having both data makes the number of data available for each quadrant uneven. For each quadrant, the mean value for the performance outcome is obtained.

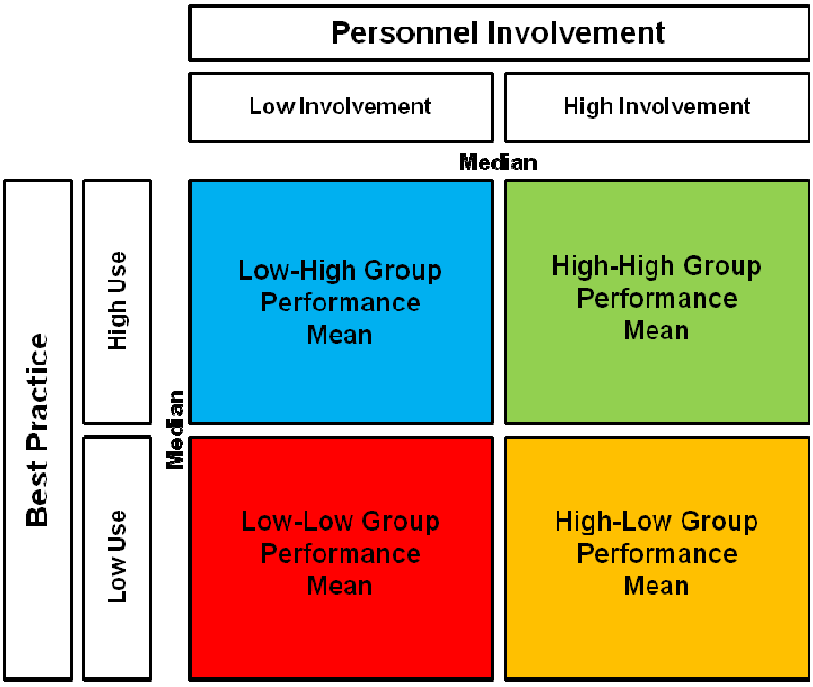


Figure 6.1 Two-way Factorial Design for Interaction Effects Analysis of PI and BP

Through use of this two-way factorial design, the research intends to confirm the third research proposition: *Projects with high involvement of the owner's management personnel and high implementation of best practices have better performance outcomes.* In other words, there is a difference in the cost growth of projects with high and low involvement of management personnel which fall into one of the two best practice implementation groups: the high use group or low use group.

The interaction effects of personnel involvement and best practices were examined. The performance outcomes used for investigating interaction effects are cost growth, schedule growth, and change cost factor. Achievement of business objectives was excluded because the data for the is too small and skewed to be applied to two-way

factorial ANOVA. As note in the previous chapter, such data are likely to violate the assumption of normal distribution as the dependent variable.

An interaction between the two factors is presented in a two-way ANOVA when the effect of the levels of one factor is not the same across the levels of the other factor. An interaction exists to the extent that the difference between the levels of the first factor changes when the level of the second factor moves to another level. There can be various patterns of interaction. This research found interactions that are related to the research proposition, as can be seen in Figure 6.2 (a). If more personnel involvement and more use of best practices have a positive impact on performance, a comparison of mean values between each quadrant should show that the high involvement/high use (high/high) quadrant would have the best performance, and the low involvement/low use (low/low) quadrant would have the worst performance. This interaction is the ordinal interaction if the levels of one independent variable never cross at any level of the other independent variable.

Another type of interaction is observed if there are significant interaction effects between the two variables and both are required to achieve a beneficial effect. In such cases, only the high/high quadrant will have the best performance and the low/low quadrant won't have the worst performance. This type of interaction is the disordinal interaction if the levels of one independent variable cross at any level of the other independent variable as shown in the Figure 6.2 (b). This interaction effect implies three important points: 1) the high/high quadrant has the best performance compared to others; 2) projects with lower use of best practices have worse performance than those with high

involvement and high use; 3) although best practices are highly used in a project, the project with lower or less personnel involvement have worse performance than those with high involvement and high use of best practices. The ordinal interaction (high/high - best; low/low - worst) is shown in bold, and the disordinal interaction (high/high - best; low/low - not worst) is shown in italic, and statistically significant interactions are shown in underlined and italic. Most statistically significant interactions have been found among disordinal interactions.

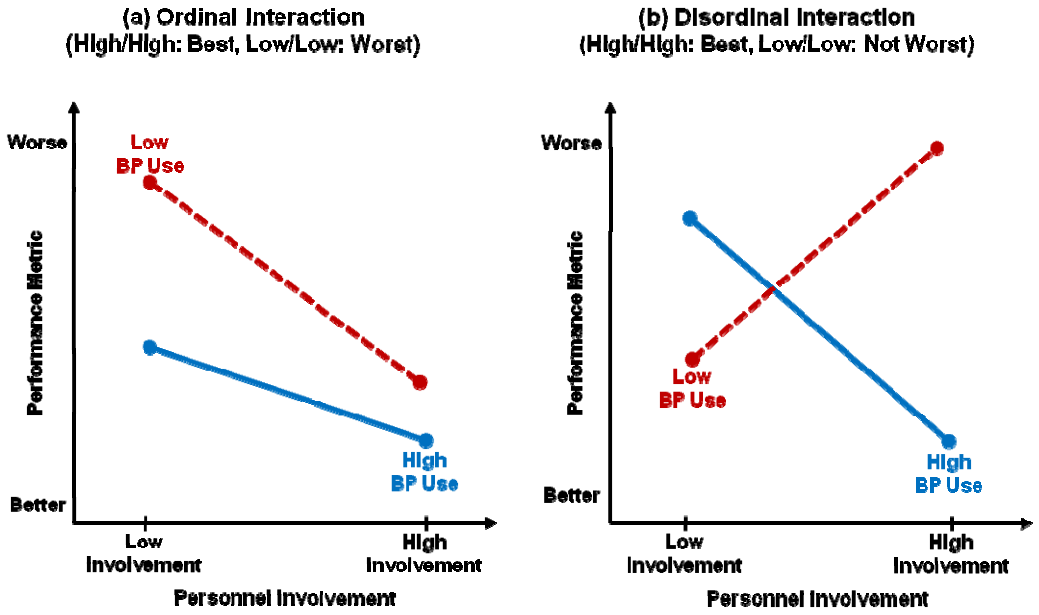


Figure 6.2 Type of Interaction Effects of PI and BP

For clarity, combinations that do not meet one of the two interaction patterns are not shown in the tables. In addition, the available data for each set of metrics may not be enough and the difference between the mean values of the four quadrants is not statistically significant in most combinations. Although some interactions are not

statistically significant, however, the results can be used as possible indicators to show important interaction effects.

6.4.2 Analysis Results

Table 6.16 summarized the interaction effects of involvement of business unit personnel and use of best practices on cost performance. It should be noted that if the combinations of personnel involvement and best practices use didn't meet the requirements for at least 3 data points in each quadrant, those combinations are not included.

The involvement of the accounting manager has two ordinal interaction effects with Project Delivery & Contract Strategy, and Planning for Startup indicating the high/high quadrant shows the best performance and the low/low quadrant shows the worst performance. Their overall improvements (high/high minus low/low) are 6.4% and 7.6%, respectively. In addition, three disordinal interactions on cost performance have been found with Front End Planning, Alignment during FEP, and Partnering. All these disordinal interactions are statistically significant at the 0.1 level. For Front End Planning, the cost performance of the projects in the high/high quadrant is 10.6% better than those in the high/low quadrant and it is 5.4% better than those in the low/high quadrant. For Alignment during FEP, the cost performance of the projects in the high/high quadrant is 10.6% better than those in the high/low quadrant and it is 4.7% better than those in the low/high quadrant. For Partnering, the cost performance of the

projects in the high/high quadrant is 10.6% better than those in the high/low quadrant and it is 4.7% better than those in the low/high quadrant.

The involvement of the finance manager also has two ordinal interaction effects with Project Delivery & Contract Strategy, and Planning for startup. Their overall improvements (high/high minus low/low) are 4.5% and 7.4%, respectively. In addition, two disordinal interactions on cost performance have been found with Front End Planning and Alignment during FEP. These two disordinal interactions are statistically significant at the 0.1 level. For Front End Planning, the cost performance of the projects in the high/high quadrant is 11.9% better than those in the high/low quadrant and it is 5.2% better than those in the low/high quadrant. For Alignment during FEP, the cost performance of the projects in the high/high quadrant is 11.9% better than those in the high/low quadrant and it is 4.1% better than those in the low/high quadrant.

The involvement of the information technology manager has two ordinal interaction effects with Project Risk Assessment and Planning for Startup. Their overall improvements (high/high minus low/low) are 3.1% and 6.2%, respectively. In addition, one disordinal interaction on cost performance has been found with Constructability. This disordinal interaction is statistically significant at the 0.1 level. For Constructability, the cost performance of the projects in high/high quadrant is 5.2% better than those in high/low quadrant and it is 7.0% better than those in low/high quadrant.

Table 6.16 Results of PI of Business Unit and BP on Project Cost Growth (in %) (Continued)

Best Practices		Business Unit Manager		Project Sponsor	
		Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use	**-7.8**	**-8.4**	***-3.5***	***-9.8***
	Low Use	**0.7**	**-1.5**	***-3.7***	***0.8***
Alignment during FEP	High Use	C.T.		***-3.5***	***-9.2***
	Low Use			***-3.7***	***1.0***
Partnering	High Use	C.T.		*-4.8*	*-7.4*
	Low Use			*-3.3*	*0.0*
Team Building	High Use			C.T.	
	Low Use				
Project Delivery & Contract Strategy	High Use	C.T.		*-2.7*	*-8.3*
	Low Use			*-3.0*	*-4.8*
Constructability	High Use	C.T.			
	Low Use				
Project Risk Assessment	High Use	**-6.3**	**-6.4**	C.T.	
	Low Use	**-2.3**	**-4.8**		
Change Management	High Use	C.T.			
	Low Use				
Zero Accident Techniques	High Use	C.T.			
	Low Use				
Planning for Startup	High Use			*0.3*	*-8.6*
	Low Use			*-1.8*	*-2.0*

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variables on performance is statistically significant at the 0.1 level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 6.16 Results of PI of Business Unit and BP on Project Cost Growth (in %) (Continued)

Best Practices		Accounting Manager		Finance Manager		Information Technology Manager	
		Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use	***-4.7***	***-10.1***	***-5.8***	***-11.0***		
	Low Use	***-2.8***	***0.5***	***-2.2***	***0.9***		
Alignment during FEP	High Use	***-4.7***	***-9.4***	***-5.8***	***-9.9***		
	Low Use	***-2.6***	***1.2***	***-2.1***	***2.0***		
Partnering	High Use	***-1.7***	***-9.6***	C.T.			
	Low Use	***-4.0***	***2.9***				
Team Building	High Use					C.T.	
	Low Use						
Project Delivery & Contract Strategy	High Use	**-5.3**	**-8.4**	**-4.7**	**-8.3**	C.T.	
	Low Use	**-2.0**	**-7.6**	**-3.8**	**-4.6**		
Constructability	High Use					***-0.6***	***-7.6***
	Low Use					***-6.9***	***-2.4***
Project Risk Assessment	High Use	C.T.				**-5.0**	**-7.0**
	Low Use					**-3.9**	**-5.1**
Change Management	High Use						
	Low Use						
Zero Accident Techniques	High Use			C.T.			
	Low Use						
Planning for Startup	High Use	**-2.3**	**-8.7**	**-3.3**	**-9.1**	**-6.4**	**-7.5**
	Low Use	**-1.1**	**-3.7**	**-1.7**	**-2.1**	**-1.3**	**-2.4**

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variables on performance is statistically significant at the 0.1 level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 6.16 Results of PI of Business Unit and BP on Project Cost Growth (in %) (Continued)

Best Practices		Facility/Plant Manager		Contract/Legal Manager		Operations/Production Manager	
		Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use	C.T.		**-7.1**	**-9.5**	*-7.2*	*-9.2*
	Low Use			**-0.7**	**-3.6**	*-2.5*	*-0.7*
Alignment during FEP	High Use	C.T.		**-7.1**	**-8.8**	*-7.2*	*-8.5*
	Low Use			**-0.8**	**-2.4**	*-2.5*	*-0.3*
Partnering	High Use	**-1.9**	**-8.7**	**-4.2**	**-8.9**	*-4.4*	*-7.8*
	Low Use	**-0.1**	**-4.7**	**-0.7**	**-5.0**	*-3.1*	*-1.2*
Team Building	High Use	C.T.		C.T.			
	Low Use						
Project Delivery & Contract Strategy	High Use	**-4.2**	**-8.5**	**-3.6**	**-8.8**	**-3.6**	**-8.8**
	Low Use	**-1.3**	**-6.2**	**-2.8**	**-6.2**	**-2.1**	**-4.7**
Constructability	High Use						
	Low Use						
Project Risk Assessment	High Use	C.T.					
	Low Use						
Change Management	High Use						
	Low Use						
Zero Accident Techniques	High Use					C.T.	
	Low Use						
Planning for Startup	High Use	C.T.		**-4.1**	**-8.0**	C.T.	
	Low Use			**-1.1**	**-3.7**		

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variables on performance is statistically significant at the 0.1 level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

In terms of the involvement of the facility/plant manager, the interaction effects on cost performance were found with Partnering and Project Delivery & Contract Strategy. Their overall improvements (high/high minus low/low) are 8.6% and 7.2%, respectively. No statistically significant interaction has been found.

The involvement of the contract/legal manager has five ordinal interaction effects with Front End Planning, Alignment during FEP, Partnering, Project Delivery & Contract Strategy, and Planning for Startup. Their overall improvements (high/high minus low/low) are 8.8%, 8.0%, 8.2%, 6.0%, and 6.9%, respectively. No statistically significant interaction has been found.

The involvement of the operations/production manager has one ordinal interaction effects with Project Delivery & Contract Strategy. The overall improvement (high/high minus low/low) is 6.7%. In addition, three disordinal interactions on cost performance have been found with Front End Planning, Alignment during FEP, and Partnering. For Front End Planning, the cost performance of the projects in the high/high quadrant is 9.7% better than those in the high/low quadrant and it is 2.0% better than those in the low/high quadrant. For Alignment during FEP, the cost performance of the projects in the high/high quadrant is 8.2% better than those in the high/low quadrant and it is 1.3% better than those in the low/high quadrant. For Partnering, the cost performance of the projects in the high/high quadrant is 6.6% better than those in the high/low quadrant and it is 3.4% better than those in the low/high quadrant.

Table 6.17 summarized the interaction effects of involvement of project unit personnel and the use of best practice on cost performance. The interaction effects were examined in terms of the project controls manager, engineering team lead, QA/QC manager, and HSE manager.

The involvement of the project controls manager has one ordinal interaction effect with Project Delivery & Contract Strategy. The overall improvement (high/high minus low/low) is 4.6%. In addition, two disordinal interactions on cost performance have been found with Front End Planning and Alignment during FEP. For Front End Planning, the cost performance of the projects in the high/high quadrant is 11.2% better than those in the high/low quadrant and it is 4.6% better than those in the low/high quadrant. For Alignment during FEP, the cost performance of the projects in the high/high quadrant is 11.1% better than those in the high/low quadrant and it is 3.8% better than those in the low/high quadrant.

The involvement of the engineering team lead has one ordinal interaction effect with Project Delivery & Contract Strategy. The overall improvement (high/high minus low/low) is 4.6%. In addition, two disordinal interactions on cost performance have been found with Front End Planning and Alignment during FEP. For Front End Planning, the cost performance of the projects in the high/high quadrant is 11.2% better than those in the high/low quadrant and it is 4.6% better than those in the low/high quadrant. For Alignment during FEP, the cost performance of the projects in the high/high quadrant is 10.7% better than those in the high/low quadrant and it is 3.8% better than those in the low/high quadrant.

Table 6.17 Results of PI of Project Unit and BP on Project Cost Growth (in %)

Best Practices		Project Controls Manager		Engineering Team Lead	
		Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use	*-5.7*	*-10.3*	*-5.7*	*-10.3*
	Low Use	*-2.2*	*0.9*	*-2.2*	*0.9*
Alignment during FEP	High Use	*-5.7*	*-9.5*	*-5.7*	*-9.5*
	Low Use	*-2.0*	*1.6*	*-2.2*	*1.2*
Partnering	High Use	C.T.		C.T.	
	Low Use				
Team Building	High Use			C.T.	
	Low Use				
Project Delivery & Contract Strategy	High Use	**-4.7**	**-8.3**	**-4.7**	**-8.3**
	Low Use	**-3.7**	**-4.3**	**-3.7**	**-4.3**
Constructability	High Use				
	Low Use				
Project Risk Assessment	High Use				
	Low Use				
Change Management	High Use				
	Low Use				
Zero Accident Techniques	High Use				
	Low Use				
Planning for Startup	High Use	C.T.		C.T.	
	Low Use				

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variables on performance is statistically significant at the 0.1 level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 6.16 Results of PI of Business Unit and BP on Project Cost Growth (in %) (Continued)

Best Practices		QA/QC Manager		HSE Manager	
		Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use	*-5.1*	*-10.0*	**-6.1**	**-11.7**
	Low Use	*-1.8*	*-0.7*	**-1.3**	**-1.8**
Alignment during FEP	High Use	*-5.1*	*-9.2*	C.T.	
	Low Use	*-1.8*	*-0.1*		
Partnering	High Use	C.T.		**-4.2**	**-10.9**
	Low Use			**-1.4**	**-3.2**
Team Building	High Use	C.T.		C.T.	
	Low Use				
Project Delivery & Contract Strategy	High Use	**-4.7**	**-8.3**	**-5.3**	**-8.4**
	Low Use	**-2.5**	**-4.9**	**-2.8**	**-7.3**
Constructability	High Use				
	Low Use				
Project Risk Assessment	High Use	C.T.		C.T.	
	Low Use				
Change Management	High Use				
	Low Use				
Zero Accident Techniques	High Use			C.T.	
	Low Use				
Planning for Startup	High Use	C.T.		**-4.1**	**-9.5**
	Low Use			**-0.3**	**-5.5**

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variables on performance is statistically significant at the 0.1 level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

The involvement of the QA/QC manager has one ordinal interaction effect with Project Delivery & Contract Strategy. The overall improvement (high/high minus low/low) is 5.8%. In addition, two disordinal interactions on cost performance have been found with Front End Planning and Alignment during FEP. For Front End Planning, the cost performance of the projects in the high/high quadrant is 10.7% better than those in the high/low quadrant and it is 4.9% better than those in the low/high quadrant. For Alignment during FEP, the cost performance of the projects in the high/high quadrant is 9.3% better than those in the high/low quadrant and it is 4.1% better than those in the low/high quadrant.

The involvement of HSE manager has four ordinal interaction effects with Front End Planning, Partnering, Project Delivery & Contract Strategy, and Planning for Startup. Their overall improvements (high/high minus low/low) are 10.4%, 9.5%, 5.6, and 9.2%. Among the project unit personnel, no statistically significant interaction effect has been found.

Table 6.18 summarized the interaction effects of involvement of business unit personnel and use of best practice on schedule performance. The interaction effects were examined in terms of business unit manager, accounting manager, finance manager, information technology manager, facility/plant manager, contract/legal manager, and operations/production manager.

The involvement of the business unit manager has one ordinal interaction effect with Team Building. The overall improvement (high/high minus low/low) is 8.1%. In addition, one disordinal interaction on schedule performance has been found with

Planning for Startup. For Planning for Startup, the schedule performance of the projects in high/high quadrant is 10.1% better than those in the high/low quadrant and it is 11.1% better than those in the low/high quadrant.

The involvement of the accounting manager has one disordinal interaction on schedule performance with Project Delivery & Contract Strategy. For Project Delivery & Contract Strategy, the schedule performance of the projects in the high/high quadrant is 11.1% better than those in the high/low quadrant and it is 9.3% better than those in the low/high quadrant.

The involvement of the finance manager has six disordinal interactions on schedule performance with Front End Planning, Alignment during FEP, Project Delivery & Contract Strategy, Constructability, Project Risk Assessment, and Planning for Startup. For Front End Planning, the schedule performance of the projects in the high/high quadrant is 8.6% better than those in the high/low quadrant and it is 15.1% better than those in the low/high quadrant. For Alignment during FEP, the high/high quadrant shows 6.7% better performance than those in the high/low quadrant and shows 15.1% better than those in the low/high quadrant. For Project Delivery & Contract Strategy, the high/high quadrant shows 7.4% better than those in the high/low quadrant and shows 18.4% better than those in the low/high quadrant. For Constructability, the high/high quadrant shows 2.0% better outcomes than those in the high/low quadrant and shows 13.8% better than those in the low/high quadrant. For Project Risk Assessment, the high/high quadrant shows 3.5% better than those in the high/low quadrant and shows 18.1% better than those in the low/high quadrant. For Planning for Startup, the high/high

quadrant shows 5.1% better than those in the high/low quadrant and shows 12.7% better than those in the low/high quadrant.

Table 6.18 Results of PI of Business Unit and BP on Project Schedule Growth (in %)

		Business Unit Manager		Project Sponsor	
		Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use	C.T.		**8.2**	**3.7**
	Low Use			**12.0**	**9.6**
Alignment during FEP	High Use	**8.8**	**0.9**	**8.2**	**3.7**
	Low Use	**11.3**	**9.6**	**12.0**	**8.2**
Partnering	High Use				
	Low Use				
Team Building	High Use	**7.1**	**3.2**		
	Low Use	**11.3**	**6.9**		
Project Delivery & Contract Strategy	High Use			*20.0*	*1.2*
	Low Use			*8.7*	*11.4*
Constructability	High Use				
	Low Use				
Project Risk Assessment	High Use	*10.4*	*2.1*		
	Low Use	*7.4*	*9.1*		
Change Management	High Use	*10.6*	*5.3*		
	Low Use	*6.9*	*7.2*		
Zero Accident Techniques	High Use				
	Low Use				
Planning for Startup	High Use	*11.3*	*0.2*	**4.5**	**4.2**
	Low Use	*7.1*	*10.3*	**13.4**	**5.3**

Table 6.18 Results of PI of Business Unit and BP on Project Schedule Growth (in %) (Continued)

Best Practice		Accounting Manager		Finance Manager		Information Technology Manager	
		Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use			*14.1*	*-1.0*		
	Low Use			*11.8*	*7.6*		
Alignment during FEP	High Use			*14.1*	*-1.0*		
	Low Use			*11.4*	*5.7*		
Partnering	High Use						
	Low Use						
Team Building	High Use	C.T.		C.T.		C.T.	
	Low Use						
Project Delivery & Contract Strategy	High Use	*9.6*	*0.3*	*17.8*	*-0.6*	*5.9*	*2.6*
	Low Use	*9.4*	*11.4*	*11.4*	*6.8*	*8.6*	*11.1*
Constructability	High Use			*14.4*	*0.6*		
	Low Use			*10.5*	*2.6*		
Project Risk Assessment	High Use	C.T.		*18.8*	*0.7*		
	Low Use			*10.3*	*4.2*		
Change Management	High Use						
	Low Use						
Zero Accident Techniques	High Use			C.T.			
	Low Use						
Planning for Startup	High Use			*12.3*	*-0.4*		
	Low Use			*12.5*	*4.7*		

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variables on performance is statistically significant at the 0.1 level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 6.18 Results of PI of Business Unit and BP on Project Schedule Growth (in %) (Continued)

Best Practice		Facility/Plant Manager		Contract/Legal Manager		Operations/Production Manager	
		Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use						
	Low Use						
Alignment during FEP	High Use						
	Low Use						
Partnering	High Use						
	Low Use						
Team Building	High Use	C.T.		*9.0*	*1.3*	C.T.	
	Low Use			*7.9*	*8.0*		
Project Delivery & Contract Strategy	High Use	*8.6*	*2.5*	*9.6*	*1.8*	*9.6*	*1.8*
	Low Use	*9.8*	*10.4*	*7.8*	*14.3*	*9.2*	*10.5*
Constructability	High Use						
	Low Use						
Project Risk Assessment	High Use	C.T.				C.T.	
	Low Use						
Change Management	High Use						
	Low Use						
Zero Accident Techniques	High Use					C.T.	
	Low Use						
Planning for Startup	High Use						
	Low Use						

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variables on performance is statistically significant at the 0.1 level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

The involvement of the information technology manager has one disordinal interaction on schedule performance with Project Delivery & Contract Strategy. For Project Delivery & Contract Strategy, the schedule performance of the projects in high/high quadrant is 13.7% better than those in the high/low quadrant and it is 3.3% better than those in the low/high quadrant.

The involvement of the facility/plant manager has one disordinal interaction on schedule performance with Project Delivery & Contract Strategy. For Project Delivery & Contract Strategy, the schedule performance of the projects in the high/high quadrant is 7.9% better than those in the high/low quadrant and it is 6.1% better than those in the low/high quadrant.

The involvement of the contract/legal manager has two disordinal interactions on schedule performance with Team Building and Project Delivery & Contract Strategy. For Team Building, the schedule performance of the projects in the high/high quadrant is 6.7% better than those in the high/low quadrant and it is 7.7% better than those in the low/high quadrant. For Project Delivery & Contract Strategy, the schedule performance of the projects in the high/high quadrant is 12.5% better than those in the high/low quadrant and it is 7.8% better than those in the low/high quadrant.

The involvement of the operations/production manager has one disordinal interaction on schedule performance with Project Delivery & Contract Strategy. For Project Delivery & Contract Strategy, the schedule performance of the projects in the high/high quadrant is 8.7% better than those in the high/low quadrant and it is 7.6% better than those in the low/high quadrant.

Table 6.19 summarized the interaction effects of involvement of project unit personnel and the use of best practice on schedule performance. The interaction effects were examined in terms of the project controls manager, engineering team lead, QA/QC manager, and HSE manager.

The involvement of the project controls manager has four disordinal interactions on schedule performance with Front End Planning, Alignment during FEP, Project Delivery & Contract Strategy, and Constructability. Among them, Front End Planning and Alignment during FEP has statistically significant interactions with the involvement of the project controls manager. For Front End Planning, the schedule performance of the projects in the high/high quadrant is 9.0% better than those in the high/low quadrant and it is 21.6% better than those in the low/high quadrant. For Alignment during FEP, the high/high quadrant shows 9.1% better than those in the high/low quadrant and it is 21.6% better than those in the low/high quadrant. For Project Delivery & Contract Strategy, the high/high quadrant shows 5.4% better than those in the high/low quadrant and it is 18.4% better than those in the low/high quadrant. For Constructability, the high/high quadrant shows 3.6% better than those in the high/low quadrant and it is 18.3% better than those in the low/high quadrant.

The involvement of the engineering team lead has four disordinal interactions on schedule performance with Front End Planning, Alignment during FEP, Project Delivery & Contract Strategy, and Constructability. Among them, Front End Planning and Alignment during FEP has statistically significant interactions with the involvement of project controls manager. For Front End Planning, the schedule performance of the

projects in the high/high quadrant is 9.0% better than those in the high/low quadrant and it is 21.6% better than those in the low/high quadrant. For Alignment during FEP, the high/high quadrant shows 7.5% better than those in the high/low quadrant and it is 21.6% better than those in the low/high quadrant. For Project Delivery & Contract Strategy, the high/high quadrant shows 5.4% better than those in the high/low quadrant and it is 18.4% better than those in the low/high quadrant. For Constructability, the high/high quadrant shows 3.6% better than those in the high/low quadrant and it is 18.3% better than those in the low/high quadrant.

The involvement of QA/QC manager has one disordinal interaction on schedule performance with Project Delivery & Contract Strategy. This interaction is statistically significant at the 0.1 level. For Project Delivery & Contract Strategy, the high/high quadrant shows 10.6% better than those in the high/low quadrant and it is 18.4% better than those in the low/high quadrant.

The involvement of the HSE manager has five ordinal interaction effects with Front End Planning, Alignment during FEP, Partnering, Project Delivery & Contract Strategy, and Planning for Startup. Their overall improvements (high/high minus low/low) are 13.5%, 11.7%, 11.9%, 12.7%, and 11.9%. No statistically significant interaction effect has been found.

Table 6.19 Results of PI of Project Unit and BP on Project Schedule Growth (in %) (Continued)

Best Practice		Project Controls Manager		Engineering Team Lead	
		Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use	***20.2***	***-1.4***	***20.2***	***-1.4***
	Low Use	***11.8***	***7.6***	***11.8***	***7.6***
Alignment during FEP	High Use	***20.2***	***-1.4***	***20.2***	***-1.4***
	Low Use	***10.7***	***7.7***	***11.8***	***6.1***
Partnering	High Use				
	Low Use				
Team Building	High Use	C.T.		C.T.	
	Low Use				
Project Delivery & Contract Strategy	High Use	*17.8*	*-0.6*	*17.8*	*-0.6*
	Low Use	*14.6*	*4.8*	*14.6*	*4.8*
Constructability	High Use	*18.1*	*-0.2*	*18.1*	*-0.2*
	Low Use	*11.1*	*3.4*	*11.1*	*3.4*
Project Risk Assessment	High Use	C.T.		C.T.	
	Low Use				
Change Management	High Use				
	Low Use				
Zero Accident Techniques	High Use				
	Low Use				
Planning for Startup	High Use	C.T.		C.T.	
	Low Use				

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variables on performance is statistically significant at the 0.1 level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 6.19 Results of PI of Project Unit and BP on Project Schedule Growth (in %) (Continued)

Best Practice		QA/QC Manager		HSE Manager	
		Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use	C.T.		**8.5**	**-0.2**
	Low Use			**13.3**	**3.4**
Alignment during FEP	High Use	C.T.		**8.5**	**-0.2**
	Low Use			**11.5**	**3.4**
Partnering	High Use	C.T.		**10.6**	**0.0**
	Low Use			**11.9**	**2.3**
Team Building	High Use	C.T.		C.T.	
	Low Use				
Project Delivery & Contract Strategy	High Use	***17.8***	***-0.6***	**9.6**	**0.3**
	Low Use	***10.4***	***10.0***	**13.0**	**2.6**
Constructability	High Use				
	Low Use				
Project Risk Assessment	High Use	C.T.		C.T.	
	Low Use				
Change Management	High Use	C.T.			
	Low Use				
Zero Accident Techniques	High Use			C.T.	
	Low Use				
Planning for Startup	High Use	C.T.		**7.2**	**0.6**
	Low Use			**12.5**	**1.9**

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variables on performance is statistically significant at the 0.1 level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

The involvement of the QA/QC manager has one ordinal interaction effect with Project Delivery & Contract Strategy. The overall improvement (high/high minus low/low) is 5.8%. In addition, two disordinal interactions on cost performance have been found with Front End Planning and Alignment during FEP. For Front End Planning, the cost performance of the projects in the high/high quadrant is 10.7% better than those in the high/low quadrant and it is 4.9% better than those in the low/high quadrant. For Alignment during FEP, the cost performance of the projects in the high/high quadrant is 9.3% better than those in the high/low quadrant and it is 4.1% better than those in the low/high quadrant.

The involvement of the HSE manager has four ordinal interaction effects with Front End Planning, Partnering, Project Delivery & Contract Strategy, and Planning for Startup. Their overall improvements (high/high minus low/low) are 10.4%, 9.5%, 5.6, and 9.2%. Among the project unit personnel, no statistically significant interaction effect has been found.

Table 6.20 summarized the interaction effects of involvement of business unit personnel and use of best practice on change performance. The interaction effects were examined in terms of the finance manager and facility/plant manager. The involvement of the finance manager has one disordinal interaction on change performance with constructability. For Constructability, the change performance of the projects in the high/high quadrant is 1.5% better than those in the high/low quadrant and it is 0.5% better than those in the low/high quadrant. The involvement of the facility/plant manager has two disordinal interactions on change performance with Change Management and

Zero Accident Techniques. For Change Management, the change performance of the projects in the high/high quadrant is 2.0% better than those in the high/low quadrant and it is 0.2% better than those in the low/high quadrant. For Zero Accident Techniques, the change performance of the projects in the high/high quadrant is 1.1% better than those in the high/low quadrant and it is 0.8% better than those in the low/high quadrant.

Table 6.20 Results of PI of Business Unit and BP on Change Cost Factor (in %)

Best Practice		Business Unit Manager		Finance Manager		Facility/Plant Manager	
		Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use					C.T.	
	Low Use						
Alignment during FEP	High Use					C.T.	
	Low Use						
Partnering	High Use						
	Low Use						
Team Building	High Use	**1.8**	**1.8**	C.T.		C.T.	
	Low Use	**4.2**	**2.8**				
Project Delivery & Contract Strategy	High Use						
	Low Use						
Constructability	High Use			*2.8*	*2.3*		
	Low Use			*2.3*	*3.8*		
Project Risk Assessment	High Use	*3.2*	*1.7*	C.T.		C.T.	
	Low Use	*2.5*	*2.7*				
Change Management	High Use	*3.4*	*1.3*			*2.3*	*2.1*
	Low Use	*2.1*	*3.8*			*2.7*	*4.1*
Zero Accident Techniques	High Use	*2.9*	*2.0*	C.T.		*2.8*	*2.0*
	Low Use	*3.4*	*2.8*			*2.3*	*3.1*
Planning for Startup	High Use					C.T.	
	Low Use						

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 6.20 Results of PI of Project Unit and BP on Change Cost Factor (in %) (Continued)

Best Practice		Project Controls Manager		Engineering Team Lead		HSE Manager	
		Low Involvement	High Involvement	Low Involvement	High Involvement	Low Involvement	High Involvement
Front End Planning	High Use						
	Low Use						
Alignment during FEP	High Use						
	Low Use						
Partnering	High Use	C.T.		C.T.			
	Low Use						
Team Building	High Use	C.T.		C.T.		C.T.	
	Low Use						
Project Delivery & Contract Strategy	High Use						
	Low Use						
Constructability	High Use					*2.7*	*2.3*
	Low Use					*2.4*	*4.0*
Project Risk Assessment	High Use	C.T.		C.T.		C.T.	
	Low Use						
Change Management	High Use	*2.4*	*2.0*	*2.4*	*2.0*		
	Low Use	*2.4*	*4.4*	*2.4*	*4.4*		
Zero Accident Techniques	High Use			*2.7*	*1.8*	C.T.	
	Low Use			*2.0*	*3.3*		
Planning for Startup	High Use	C.T.		C.T.			
	Low Use						

Bold indicates high-high quadrant shows the best performance and low-low quadrant shows the worst performance.
Italic indicates high-high quadrant shows the best performance but low-low quadrant does not show the worst performance.
Underlined and italic indicates that the interaction effect of two variables on performance is statistically significant at the 0.1 level.
Number of data used for each test ranges 20 to 35. Number of data for each quadrant ranges 3 to 14.
C.T. Data withhold per CII confidentiality policy (less than 10 projects or data submitted by less than 3 companies).

Table 6.21 summarized the interaction effects of involvement of project unit personnel and the use of best practices on change performance. The interaction effects were examined in terms of the project controls manager, engineering team lead, and HSE manager. The involvement of the project controls manager has one disordinal interaction on change performance with Change Management. For Change Management, the change performance of the projects in the high/high quadrant is 2.4% better than those in the high/low quadrant and it is 0.4% better than those in the low/high quadrant.

The involvement of the engineering team lead has two disordinal interactions on change performance with Change Management and Zero Accident Techniques. For Change Management, the change performance of the projects in the high/high quadrant is 2.2% better than those in the high/low quadrant and it is 0.4% better than those in the low/high quadrant. For Zero Accident Techniques, the change performance of the projects in the high/high quadrant is 1.5% better than those in the high/low quadrant and it is 0.9% better than those in the low/high quadrant.

The involvement of the HSE manager has one disordinal interaction on change performance with Constructability. For Constructability, the change performance of the projects in the high/high quadrant is 1.7% better than those in the high/low quadrant and it is 0.4% better than those in the low/high quadrant.

6.5 DISCUSSIONS

This chapter tests the third research question, "Does the business-project interface enhance the value of best practices?" The chapter investigates the relationships of personnel involvement and best practices, and the interaction effects of personnel involvement and best practices on major performance metrics. Three main propositions developed in this chapter provide the individual and leveraged impacts of the business-project interface on the value of best practices. The first proposition examines which personnel involvement facilitates implementation of best practices. Existing CII studies have pointed out that business executives and functional managers are essential to successful implementation of best practices in an organization (CII 2009). The second research proposition, whether best practices account for improved performance outcomes, is also well proven by CII studies (CII 2003b; CII 2010). In addition, the third proposition proposes the combined effects of key personnel's involvement and best practices implementation on performance outcomes.

Table 6.21 summarizes the propositions and findings of research question three. Proposition 3-1, which states that there is a relationship between the owner's personnel involvement and the implementation levels of best practices, was well-supported by the findings. Most management personnel were found to have positive and statistically significant associations with best practices, particularly front end planning, alignment during FEP, partnering, team building, project delivery & contract strategy, and project risk assessment. The remaining four best practices including constructability, change

management, zero accident techniques, and planning for startup had only a few statistically significant relationships with personnel involvement.

On the other hand, Proposition 3-2, which stated that there are relationships between best practices implementation and performance outcomes, was supported by the findings in a limited fashion, as show in Table 6.22. Most association between best practices and performance outcomes had positive associations, but statistically significant results were found only for front end planning, alignment during FEP, and partnering.

Based on the findings of the two previous propositions, Proposition 3-3, which asserts the interaction effects of personnel involvement and best practices on performance outcomes were tested. This proposition is well-supported by the findings, as shown in Table 6.22. When personnel involvement and best practices were taken into account concurrently, numerous meaningful interactions among them were found. However, few limited interactions had statistically significant results at the 0.1 significance level. Nevertheless, these findings support the notion that significant business-project alignment enhances the value of best practices. Significant interaction seems to nurture important managerial focus, which is required for best practices to be implemented fully and effectively. The findings summarized in Table 6.22 show various leveraging effects of personnel involvement and best practices implementation on performance outcomes. Moreover, the results support the tentative conclusion that more statistically significant results will be found, once more data are obtained.

Table 6.21 Summary of Propositions and Findings for Research Question Three

Proposition 3-1: The more the owner's management personnel interface with a capital project, the better the implementation of best practices.

Findings:

- Most involvements of owner's management personnel show positive association with implementation level of best practices.
- Front End Planning shows positive association with the involvement of finance manager, facility/plant manager, project controls manager, engineering manager, engineering team lead, procurement manager, and QA/QC manager, and the associations are statistically significant.
  - For the cost category of $5MM-$50MM, Front End Planning is positive associated with finance manager, information technology manager, facility/plant manager, and engineering manager and the associations are statistically significant.
  - For the cost category of greater than $50MM, no statistically significant association has been found between personnel involvement and Front End Planning.
- Alignment during FEP shows positive association with the involvement of finance manager, facility/plant manager, project controls manager, engineering team lead, and QA/QC manager, and the associations are statistically significant.
  - For the cost category of $5MM-$50MM, Alignment during FEP is positive associated with finance manager, information technology manager, facility/plant manager, and engineering manager and the associations are statistically significant.
  - For the cost category of greater than $50MM, no statistically significant association has been found between personnel involvement and Alignment during FEP.
- Partnering shows positive association with the involvement of project sponsor, finance manager, information technology manager, facility/plant manager, project controls manager, engineering manager, engineering team lead, procurement manager, construction manager, QA/QC manager, and HSE manager and the associations are statistically significant.
  - For the cost category of $5MM-$50MM, Alignment during FEP is positive associated with project sponsor, accounting manager, finance manager, facility/plant manager, contract/legal manager, project controls manager, engineering manager, engineering team lead, procurement manager, and QA/QC manager and the associations are statistically significant.
  - For the cost category of greater than $50MM, no statistically significant association has been found between personnel involvement and Partnering.
- Team Building shows positive association with the involvement of finance manager, human resource manager, information technology manager, facility/plant manager, operations/production manager, portfolio/program manager, engineering manager,

and procurement manager, and the associations are statistically significant.
  - For the cost category of $5MM-$50MM, no statistically significant association has been found between personnel involvement and Team Building.
  - For the cost category of greater than $50MM, Team Building is positive associated with human resource manager, information technology manager, operations/production manager, and portfolio/program manager, and the associations are statistically significant.
- Project Delivery & Contract Strategy shows positive association with the involvement of accounting manager, finance manager, project controls manager, and engineering manager, and the associations are statistically significant.
  - For both of the cost category of $5MM-$50MM and greater than $50MM, no statistically significant association has been found between personnel involvement and Team Building.
- Constructability shows positive association with the involvement of project sponsor and information technology manager, and the associations are statistically significant.
  - For the cost category of $5MM-$50MM, Constructability is positively associated with information technology manager and the association is statistically significant.
  - For the cost category of greater than $50MM, no statistically significant association has been found between personnel involvement and Constructability.
- Project Risk Assessment shows positive association with the involvement of project sponsor, accounting manager, finance manager, human resource manager, facility/plant manager, contract/legal manager, operations/production manager, portfolio manager, project controls manager, engineering manager, engineering team lead, procurement manager, QA/QC manager, and HSE manager, and the associations are statistically significant.
  - For the cost category of $5MM-$50MM, Project Risk Assessment is positive associated with project sponsor, accounting manager, finance manager, information technology manager, facility/plant manager, engineering manager, and procurement manager and the associations are statistically significant.
  - For the cost category of greater than $50MM, Project Risk Assessment is positively associated with finance manager and facility/plant manager and the associations are statistically significant.
- Change Management shows positive association with the involvement of finance manager, and the association is statistically significant.
  - For the cost category of $5MM-$50MM, Change Management is positive associated with information technology manager and the association is statistically significant.
  - For the cost category of greater than $50MM, no statistically significant association has been found between personnel involvement and Change Management.
- Zero Accident Techniques shows positive association with the involvement of information technology manager, and the association is statistically significant.

- For both of the cost category of $5MM-$50MM and greater than $50MM, no statistically significant association has been found between personnel involvement and Zero Accident Techniques.

- Planning for Startup shows positive association with the involvement of project controls manager, and the association is statistically significant.
  - For the cost category of $5MM-$50MM, Planning for Startup is positive associated with project sponsor, accounting manager, contract/legal manager, project controls manager, and engineering manager, and the associations are statistically significant.
  - For the cost category of greater than $50MM, no statistically significant association has been found between personnel involvement and Planning for Startup.

Proposition 3-2: The more the implementation of best practices, the better the performance outcomes.

Findings:

- For all project data, most uses of practices are positively associated with cost, schedule, change, and business performance.
  - Front End Planning and Alignment during FEP show positive associations with cost, schedule, and business performance, and the associations are statistically significant.
  - Partnering shows positive association with cost, schedule, and business performance, but it has statistically significant association with only cost performance.
  - Team Building, Constructability and Change Management show positive association with change performance but the associations are not statistically significant.
  - Project Delivery & Contract Strategy shows positive association with schedule performance but the association is not statistically significant.
  - Project Risk Assessment shows positive association with business performance but the association is not statistically significant.
  - Planning for Startup shows positive association with cost, schedule, and business performance but these associations are not statistically significant.
- For the cost category of $5MM-$50MM, most uses of practices are positively associated with cost, schedule, and business performance except change performance.
  - Front End Planning, Alignment during FEP, and Partnering show positive associations with cost, schedule, and business performance, and the associations are statistically significant except cost performance.
  - Project Delivery & Contract Strategy shows positive association with schedule performance but the association is not statistically significant.
  - Project Risk Assessment shows positive association with schedule and business performance but the associations are not statistically significant.
  - Zero Accident Techniques shows positive association with cost performance but

the association is not statistically significant.
- Planning for Startup shows positive association with cost, schedule, and business performance but it has statistically significant association with only business performance.

Proposition 3-3: Projects with high involvement of business unit personnel and high use of best practices have better performance outcomes.

Findings:

- Projects with high involvement of business unit manager and high use of the following best practices show improved cost, schedule, and change performance:
  - Cost performance: Front End Planning, and Project Risk Assessment
  - Schedule performance: Alignment during FEP, Team Building, Project Risk Assessment, Change Management, and Planning for Startup
  - Change performance: Team Building, Project Risk Assessment, Change Management, and Zero Accident Techniques
  - Among them, there is no statistically significant interaction.
- Projects with high involvement of project sponsor and high use of the following best practices show improved cost and schedule performance:
  - Cost performance: Front End Planning, Alignment during FEP, Partnering, Project Delivery & Contract Strategy, Planning for Startup
  - Schedule performance: Front End Planning, Alignment during FEP, Project Delivery & Contract Strategy, and Planning for Startup
  - Among them, interactions of the involvement of project sponsor and the use of Front End Planning and Alignment during FEP are statistically significant.
- Projects with high involvement of accounting manager and high use of the following best practices show improved cost and schedule performance:
  - Cost performance: Front End Planning, Alignment during FEP, Partnering, Project Delivery & Contract Strategy, Planning for Startup
  - Schedule performance: Project Delivery & Contract Strategy
  - Among them, interactions of the involvement of accounting manager and the use of Front End Planning, Alignment during FEP, and Partnering are statistically significant.
- Projects with high involvement of finance manager and high use of the following best practices show improved cost, schedule, change performance:
  - Cost performance: Front End Planning, Alignment during FEP, Project Delivery & Contract Strategy, and Planning for Startup
  - Schedule performance: Front End Planning, Alignment during FEP, Project Delivery & Contract Strategy, Constructability, Project Risk Assessment, and Planning for Startup
  - Change performance: constructability
  - Among them, interaction of the involvement of finance manager and the use of Alignment during FEP is statistically significant.
- Projects with high involvement of information technology manager and high use of

the following best practices show improved cost and schedule performance:
  - Cost performance: Constructability, Project Risk Assessment, and Planning for Startup
  - Schedule performance: Project Delivery & Contract Strategy
  - Among them, interaction of the involvement of information technology manager and the use of Constructability is statistically significant.
- Projects with high involvement of facility/plant manager and high use of the following best practices show improved cost, schedule, and change performance:
  - Cost performance: Partnering, and Project Delivery & Contract Strategy
  - Schedule performance: Project Delivery & Contract Strategy
  - Change performance: Change Management and Zero Accident Techniques
  - Among them, no statistically significant interaction has been found.
- Projects with high involvement of contract/legal manager and high use of the following best practices show improved cost and schedule performance:
  - Cost performance: Front End Planning, Alignment during FEP, Partnering, Project Delivery & Contract Strategy, Planning for Startup
  - Schedule performance: Team Building, and Project Delivery & Contract Strategy
  - Among them, no statistically significant interaction has been found.
- Projects with high involvement of operations/production manager and high use of the following best practices show improved cost and schedule performance:
  - Cost performance: Front End Planning, Alignment during FEP, Partnering, and Project Delivery & Contract Strategy
  - Schedule performance: Project Delivery & Contract Strategy
  - Among them, no statistically significant interaction has been found.

CHAPTER 7: DISCUSSIONS AND CONCLUSIONS

This chapter summarizes the major findings from this research. Research questions and their propositions are reviewed, and the findings from testing the research questions are summarized and discussed. This dissertation concludes with academic and practical contributions as drawn up by this research. Limitations and recommendations for future research are provided.

7.1 REVIEW OF RESEARCH QUESTIONS AND FINDINGS

This research addressed three research questions. Findings from each chapter are presented to address each of the research questions and their propositions.

7.1.1 Research Question One

The first research question asks "What business-project interface exist in the development of a capital project?" The question is addressed quantitatively by survey data collected through questionnaire survey. Based on the conceptual framework for identifying the business-project interface, the data assessing the involvement of business and project unit personnel and task-based interaction were used for the descriptive study discussed in Chapter 4.

First, the involvement of the owner's management personnel was assessed through personnel involvement assessment using total work-hours spent for a capital project. The descriptive statistics of personnel involvement indicates that an owner organization involves both business and project unit personnel in the development of a

capital project. The results show that greater than 50% of the business unit personnel are involved in a project and 52.4% spent 1-400 hours for development of a capital project. Among the business unit personnel, the business unit manager, project sponsor, finance manager, contract/legal manager, facility/plant manager, operations/production manager are involved in a project throughout its life cycle. From the phase level involvement analysis of management personnel, the percent participation rate of senior management personnel peaks at business planning, drops gradually during front end planning and project execution, and drops drastically as the project gets close to project close-out. The rate of functional management personnel involvement seems to remain steady across the project life cycle. Otherwise, the rate of project management personnel is low during business planning, peak at project execution, and drops notably at project close-out. These results are in alignment with typical cost and staffing levels across the project life cycle, as presented in the Project Management Body of Knowledge.

Second, the task-based interactions between the business and project unit were evaluated through task interaction assessment using Likert scales. The descriptive statistics indicate that business and project unit personnel interact with each other throughout the project life cycle. The results reveal interaction on about 60% of work functions. Highly ranked task interactions include feasibility analysis, project definition, funding, and controls, while lower ranked task interactions are in specialized functional areas as market analysis, human resource management, management information system, and execution tasks such as construction, procurement, project close-out, and permitting. From the phase level interaction analysis, business-project interaction is low during

business planning, peak at front end planning and drops gradually as the project draws to a close to project termination.

Third, the 449 valid relationships found to exist between personnel involvement and task interaction were tested using simple correlation. The simple correlations between them indicate that the more the business personnel are involved in a capital project, the more the business and project unit interact with each other. The results shows that business personnel involvement had a positive association with task interaction between the business and project unit and some limited relationships showed statistically significant results in terms of project definition, funding, and controls. These quantified findings contributed to understanding the effects of the business-project interface on performance outcomes discussed in Chapter 5.

7.1.2 Research Question Two

The second research question asks “Does the business-project interface affect project performance outcomes?” The question is addressed quantitatively by survey data collected through questionnaire survey and capital project data extracted from the CII Benchmarking & Metrics database. The data assessing the involvement of business and project unit personnel, task-based interaction, and performance metrics were used for the correlational study in Chapter 5.

First, simple correlations between personnel involvement and performance outcomes indicate that the greater the involvement of owner’s management personnel, the

better the performance outcomes. This is evidence for the direct impacts of personnel involvement on performance outcomes. The results show that most management personnel were found to have positive associations with performance outcomes and some limited results had statistically significant results in terms of schedule and business performance.

Second, the simple correlations between task interaction and performance outcomes indicate that the more the business and project units interact with each other, the better the performance outcomes. This is an evidence for the direct impacts of task interaction on performance outcomes. The results show that some limited associations between task interaction and performance outcome were positive and statistically significant results were found in terms of cost and schedule performance.

Third, the interaction effects of personnel involvement and task interaction on performance outcomes indicate that projects with high involvement of business unit personnel and high interaction between business and project unit have better performance. This is an evidence for synergy effects of personnel involvement and task interaction on performance. The results show when business personnel are more involved in a project and business and project unit interact more with each other, the project groups tend to have improved performance as compared to other groups. However, not all combinations of personnel involvement and task interaction produced the same benefits and few interactions were statistically significant. More studies should show better results in the future when more data are collected.

7.1.3 Research Question Three

The third research question asks “Does the business-project interface enhance the value of best practices?” The question is addressed quantitatively by survey data collected through questionnaire survey and best practice implementation scores data extracted from CII Benchmarking & Metrics database. The data assessing the involvement of business and project unit personnel, best practices, and performance metrics were used for the correlational study in Chapter 6.

First, the simple correlations between personnel involvement and best practices indicate that the greater the involvement of owner’s management personnel, the better the implementation of best practices. This is an evidence for the direct impacts of personnel involvement on best practices implementation. The results show that most management personnel were found to have positive and statistically significant associations with best practices implementation in terms of front end planning, alignment during FEP, partnering, team building, project delivery & contract strategy, and project risk assessment.

Second, the simple correlations between best practices implementation and performance outcomes indicate that increased implementation of best practices is associated with better performance outcomes. This is an evidence for the value of best practices discussed in existing CII research. The results show that most associations between best practices and performance outcome were positive but only three best practices had statistically significant associations with cost, schedule, and business performance.

Third, the interaction effects of personnel involvement and best practices implementation on performance outcomes indicate that projects with high involvement of business unit personnel and high implementation of best practices have better performance. This is an evidence for the leveraging effects of personnel involvement on the value of best practices. The results show when business personnel are more involved in a project and best practices are well-implemented, the project groups tend to have superior performance than other groups. However, not all combinations of personnel involvement and best practices produced the same benefits and only some limited interactions were statistically significant. More studies should show better results in the future when more data are collected.

7.2 CONTRIBUTIONS

While the findings presented in this research are not able to clarify every issue regarding the business-project interface and its impacts on performance and the value of best practices, it makes several contributions to the body of project management knowledge.

7.2.1 Academic Contributions

The first academic contribution is that this is the first study identifying business-project interfaces and quantifying their interfaces with a holistic view. Most existing studies focused on inter-organizational interfaces amongst project participants such as

owner vs. contractor, owner vs. designer, designer vs. contractor, and others. Some studies dealing with business-project interfaces were conducted through qualitative approaches such as case studies or in-depth interviews. This research provides the framework for identifying the business-project interface which is comprised of quantitative information on personnel involvement and task-based interaction in the development of a capital project. The quantitative information can be used in various research areas such as stakeholder management, social network analysis, interface management systems and practices.

The second academic contribution of this research is quantitatively showing synergy effects of personnel involvement and task interaction on performance outcomes in terms of various business and project unit personnel. Some case studies investigating impacts of roles of business unit personnel on performance focused on the specific interfaces issues and their effects on performance have employed qualitative approaches. This research provides the evidence how the business-project interfaces affect performance outcomes using a quantitative approach. The analysis results presented in this research provides a foundation to investigate the impact of the business-project interface considering personnel involvement and task interaction.

The third academic contribution is quantitatively showing leverage effects of the business-project alignment on the value of best practices. The value of best practices represents the benefits of performance improvement by implementing best practices. Existing CII studies quantitatively showed the value of best practices and emphasized the roles of the business executives and functional managers in implementing best practices.

Analysis results presented in this study provide key management personnel information to facilitate better implementation of best practices and to enhance the value of best practices.

7.2.2 Practical Contributions

The first practical contribution is related to the first academic contribution. Practitioners now have a quantitative assessment tool that can be used to measure the business-project interface in terms of personnel involvement and task interaction. This tool enables practitioners to identify and quantify the current state of the business-project interface within their organizations during the development of a capital project. In addition, the assessment tool helps them understand the interfaces by which management personnel are involved in a capital project, and which tasks require interaction between the business and project unit. The descriptive statistics from the assessment can be used as benchmarks to compare their organization's current level to others.

The second practical contribution is to provide managerial focus on the need to allocate organizational resources and effort on achieving business-project alignment throughout capital project delivery. This contribution is associated with the second academic contribution. Basically, not all management personnel are involved in all work functions during capital project delivery. To effectively manage business-project interfaces, practitioners need to target those tasks that require interaction of certain business unit personnel. Therefore, these findings provide guidance for the development

of an organizational strategy that supports business-project alignment to optimize the organizational resources in the capital investment, in accordance with corporate strategy.

The third practical contribution is providing an organizational strategy to optimize the value of best practices through the involvement of key management personnel. This contribution is also related to the third academic contribution. In existing literature, most studies emphasized that best practices require strong support of business unit personnel. The analysis results help practitioners improve their understanding of the value of best practices via personnel involvement. Therefore, the findings provide insight into selection of the right personnel and the right best practices which lead to improved performance.

7.3 LIMITATIONS AND FUTURE RESEARCH

Despite several contributions to both academia and industry, this research has some limitations. The limitations are found in terms of data sources, sample size, research scope, and specialized management practices for business-project alignment.

The first limitation is a limited scope of research. As stated in the introduction section, this research was applied to owner industrial capital projects, extracted from the CII Benchmarking & Metrics database. Most CII owner companies are large-sized and leading companies in the capital project industry. The findings from this research may represent the large company perspective rather than that of a small or medium-sized company. In addition, the business-project interface will likely have different features in contractor organizations because their business unit personnel have different roles and

responsibilities from their counterparts in owner organizations. Their business-project interface was not included in this research.

The second limitation is sample size. As shown in Chapter 4, some personnel's involvement is highly correlated with project size. That is, key personnel spent more work-hours in large projects than in small projects. The involvement patterns of the management personnel will be different by project size. Due to insufficient sample size, this research was not able to test all propositions by project characteristics and cost categories, particularly for interaction effects, because the minimum data point of each quadrant was 3. Some combinations did not meet this requirement and were excluded from the analyses. In addition, a few limited combinations showed statistically significant results at the 0.1 significance level. Therefore, a larger sample size will help to further investigate the effects of the business-project interface by cost categories as well as by other project characteristics.

The third limitation is that this research did not include organizational assets and project strategy, which may affect the business-project interface. The business-project interface may be affected by organizational assets such as organizational culture and structure, communication style and norms, and stage-gated processes as well as project strategies such as project nature, project size, project location, facility type, and project delivery method, which are usually determined in the early stage of the project life cycle. This research lacks the ability to explain the influence factors affecting the business-project interface.

Finally, this research does not provide interface management practices for improving business-project alignment but measure the current states of business-project interface and investigate their impacts on capital project performance and value of best practices because of a lack of information on business-project interface. Based on the findings from this research, therefore, future research can develop interface management practices by specific personnel, business function, and phases for strategic business-project alignment in the development of a capital project.

These limitations can be good points of departure for future research. To understand the contractor's business-project interface, the investigation of contractor-based business-project interface is recommended. Additional data will enable specifying the business-project interface by various project strategies such as for project nature, project size, project location. Project size is highly related to the levels of personnel involvement and task interaction for management efforts in the business-project interfaces. Therefore, additional data will help to figure out the business-project interface in small, medium, and large projects, respectively. Finally, the business-project interface may exist differently by various influence factors such as organizational assets and project strategies. Further studies investigating influence factors affecting the business-project interface are recommended.

APPENDICES

APPENDIX A: BUSINESS PROJECT INTERFACE QUESTIONNAIRE

Construction Industry Institute®

"Quantification of Effective Organizational Interface Management in the Development of Capital Projects"

Research Survey

Introduction to the Survey

The purpose of this survey is to assess involvement of business and project personnel and the level of their interaction in the development of capital projects. This survey contains additional questions for the following project that has been completed and submitted to the CII Benchmarking and Metrics database.

Project Information

CII ID:
Company Name:
Project Name:

Respondents may include the Benchmarking Manager, Benchmarking Associate or senior Project Manager of this project. If you believe that someone else is in a better position than yourself to answer certain sections of the questionnaire, please feel free to distribute it to that person for completing those sections. Please make sure that the questionnaire is returned to you for completion and submission to CII. (e-mail: smyun@mail.utexas.edu)

Instructions

Please respond to each section. If a question or a section does not apply to you and your organization, you will be instructed to skip that question or section. Instructions are provided in the questionnaire indicating when that is the case. When a question is preceded by an instruction, the instruction applies only to that question. If you don't know the answer to a question, indicate "Don't Know" and proceed to the next question. While we are seeking a project level perspective in this study, we understand that some of our member companies are so large that no individual respondent will be able to respond to all of the questions for the company as a whole. In those situations, please feel free to respond for the unit or division in which you work or represent or for the segment of the company for which you are most familiar.

In Section I, we are trying to determine the amount of interaction, by task, that key business and project personnel have with each other. Specifically, we are examining both the nature of the interaction itself and the strength of its influence in driving the project toward its business and technical objectives. Accordingly, to rate each task, please use the following scale:

0 – No Interaction: No involvement amongst business and project personnel.
1 – Very Poor Interaction: Rare and involuntary collaboration amongst personnel.
2 – Poor Interaction: Occasional and involuntary collaboration amongst personnel.
3 – Moderate Interaction: Occasional and voluntary collaboration amongst personnel.
4 – Good Interaction: Frequent and voluntary collaboration amongst personnel.
5 – Very Good Interaction: Continuous and voluntary collaboration amongst personnel.
N/A – Not Applicable.
D/K – Don't Know.

You can be assured that all responses will be kept confidential. No company specific results will be published. The data from the questionnaires will be entered into a database for aggregate analysis. The only results that will be published are aggregate results.

If you have questions, please contact Sungmin Yun at (512) 232-3051 or, by e-mail, at smyun@mail.utexas.edu.
Thank you for your participation in this important research activity at CII.

Section I - Task Interaction Assessment

Please indicate the involvement of business and project unit personnel in the corresponding tasks. Next, assess the level of interaction among the business unit and project unit personnel for each task listed using the 0-5 scale defined below.

Example: Planning and Execution Tasks		Unit Involvement		Level of Interaction							
		Business	Project	0	1	2	3	4	5	N/A	D/K
	Project Scope Definition	☒	☒	☐	☐	☐	☒	☐	☐	☐	☐

0 - No Interaction 2 - Poor Interaction 4 - Good Interaction N/A - Not Applicable

1 - Very Poor Interaction 3 - Moderate Interaction 5 - Very Good Interaction D/K – Don't Know

Planning and Execution Tasks			Unit Involvement		Level of Interaction							
			Business	Project	0	1	2	3	4	5	N/A	D/K
Business Planning		Corporate Goal Setting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Strategic Planning	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Market Analysis	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Priority Setting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Opportunity Identification	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Capital Budgeting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Front End Planning	Feasibility Analysis	Financial Appraisal	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Economic Feasibility Study	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Technical Feasibility Study	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Social Impact Analysis	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Environmental Impact analysis	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Concept Development	Manufacturing Objectives Criteria	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Business Objectives	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Basic Data R&D	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Project Scope	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Value Engineering	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Detailed Scope	Site Information	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Procurement Strategy	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Project Execution Plan	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Project Execution		Project Management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Estimating	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Cost Management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Accounting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Scheduling	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Communication	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Management Information Systems	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Risk Management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Contracting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Permitting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Funding Requests	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Change Management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		HSE	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Claims Management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		QA/QC	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Human Resource Management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Detailed Engineering	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Procurement	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Construction	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Startup/Commissioning	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Project Close-out			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Section II – Personnel Involvement Assessment

Please indicate the involvement of key personnel in **this project**. If applicable, also indicate the approximate work-hours of the key personnel and the proportion of their involvement in each activity. If other key personnel are not in the list, please add them.

***EXAMPLE**: If a Project Sponsor was involved with **this project** for approximately 100 work hours, and he/she spent 85% of total work hours in business planning, 10% in feasibility analysis, and 5% in conceptual development, then the involvement of the Project Sponsor should be represented as follows. Note that the sum of the percentages should equal 100%.*

	Total Work-Hours					Front End Planning				
Key Business and Project Personnel	0 Hours	1-40 Hours	41-400 Hours	401 + hours	Business Planning	Feasibility Analysis	Concept Development	Detailed Scope	Project Execution	Project Close-out
Project Sponsor / Executive Sponsor / Business Sponsor	☐	☐	☒	☐	85%	10%	5%	0%	0%	0%

	Total Work-Hours					Front End Planning				
Key Business and Project Personnel	0 Hours	1-40 Hours	41-400 Hours	401 + hours	Business Planning	Feasibility Analysis	Concept Development	Detailed Scope	Project Execution	Project Close-out
Business Unit Manager	☐	☐	☐	☐						
Chief Executive Officer	☐	☐	☐	☐						
Project Sponsor / Executive Sponsor / Business Sponsor	☐	☐	☐	☐						
Accounting Manager	☐	☐	☐	☐						
Finance Manager	☐	☐	☐	☐						
Marketing/Sales Manager	☐	☐	☐	☐						
Human Resource Manager	☐	☐	☐	☐						
Information Technology Manager	☐	☐	☐	☐						
Facility/Plant Manager	☐	☐	☐	☐						
Contract & Legal Manager	☐	☐	☐	☐						
Operations/Production Manager	☐	☐	☐	☐						
Portfolio/Program Manager	☐	☐	☐	☐						
Project Manager	☐	☐	☐	☐						
Project Controls Manager / Engineer	☐	☐	☐	☐						
Engineering Manager	☐	☐	☐	☐						
Engineering Team Discipline Leads	☐	☐	☐	☐						
Procurement Manager	☐	☐	☐	☐						
Construction Manager	☐	☐	☐	☐						
Quality Control / Quality Assurance Manager	☐	☐	☐	☐						
Health, Safety, and Environment (HSE) Manager	☐	☐	☐	☐						
Other (List):	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						

Section III – Personnel –Work Function Relationship Matrix

Please check boxes (x) of work functions that key personnel typically participated in the development of a capital project. Personnel's participation includes any activities spending their time (work-hours) for developing and executing a capital project such as meeting, phone call, faxes, e-mail, monitoring, supervision, documentation, and review and approval of requests.

Work Function \ Key Personnel		Business Unit Personnel												Project Unit Personnel							
		Business Unit Manager	Chief Executive Officer	Project Sponsor	Accounting Manager	Finance Manager	Marketing /Sales Manager	Human Resource Manager	Information Technology Manager	Facility /Plant Manager	Contract /Legal Manager	Operations /Production Manager	Program /Portfolio Manager	Project Manager	Project Controls Manager	Engineering Manager	Engineering Team Discipline Lead	Procurement Manager	Construction Manager	QA/QC Manager	HSE Manager
Business Planning	Corporate Goal Setting																				
	Strategic Planning																				
	Market Analysis																				
	Priority Setting																				
	Opportunity Identification																				
	Capital Budgeting																				
Front End Planning – Feasibility Analysis	Financial Appraisal																				
	Economic Feasibility Study																				
	Technical Feasibility Study																				
	Social Impact Analysis																				
	Environmental Impact analysis																				
Front End Planning – Concept Development	Manufacturing Objectives Criteria																				
	Business Objectives																				
	Basic Data R&D																				
	Project Scope																				
	Value Engineering																				
Front End Planning – Detail Scope	Site Information																				
	Procurement Strategy																				
	Project Execution Plan																				
Project Execution	Project Management																				
	Estimating																				
	Cost Management																				
	Accounting																				
	Scheduling																				
	Communication																				
	Management Information Systems																				
	Risk Management																				
	Contracting																				
	Permitting																				
	Funding Requests																				
	Change Management																				
	HSE																				
	Claims Management																				
	QA/QC																				
	Human Resource Management																				
	Detailed Engineering																				
	Procurement																				
	Construction																				
	Startup/Commissioning																				
Project Close-out																					

Thank you for your participation in this important research activity at CII.

4

Supplementary Assessment

(Environment and Culture) Does your company have a culture of fostering good interactions amongst the business and project personnel during the front-end planning and execution?

☐ Yes ☐ No ☐ Don't Know

(Communication Method) What communication method was typically used to facilitate interactions amongst the business and project personnel on this project?

☐	Interactive communication. (Meetings, Phone Calls, Video Conferencing, etc.)
☐	Push communication (Letters, memos, reports, e-mails, faxes, voice mails, press release, etc.)
☐	Pull communication (Intranet sites, e-learning, and knowledge repositories, etc.)
☐	Don't Know

(Communication Effectiveness) How would you assess the effectiveness of communications amongst the business and project personnel during the front-end planning and execution of this project?

Ineffective	Rarely Effective	Somewhat Effective	Effective	Very Effective	Don't Know
☐	☐	☐	☐	☐	☐

(Stage Gate Approval Process) Were the interactions and alignment activities amongst the business and project personnel incorporated within a stage gate approval process at your company?

☐ Yes ☐ No ☐ Don't Know

(Stipulated Interaction) Does your company's stage gate approval process stipulate necessary interaction activities amongst the business and project personnel by function?

☐ Yes ☐ No ☐ Don't Know

(Number of Stage Gates) How many stage gates did your company undertake during the front-end planning and execution of this project?

None	1	2-3	4-5	6-7	8 or more	Don't Know
☐	☐	☐	☐	☐	☐	☐

(Stage Gate Funding) Is your company's stage gate approval process primarily used to allocate money throughout a project's development (front-end planning through execution and startup)?

☐ Yes ☐ No ☐ Don't Know

(Project Cancellation) What percent (%) of your company's projects are typically canceled as a result of stage gate approval process reviews/decisions?

0%	1-5%	6-10%	11-20%	21-40%	Greater than 41%	Don't Know
☐	☐	☐	☐	☐	☐	☐

(Decision Quality) The stage gate approval process fostered good decision-making on this project.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Don't Know
☐	☐	☐	☐	☐	☐

Thank you for your participation in this important research activity at CII.

APPENDIX B: MAJOR TASK LEVEL INVOLVEMENT OF MANAGEMENT PERSONNEL

Phase	Work Function	Senior Management Personnel	Functional Management Personnel	Project Management Personnel
Business Planning	Corporate Goal Setting	• **Chief Executive Officer** • **Business Unit Manager** • Project Sponsor	• Finance Manager • Marketing/Sales Manager • Human Resource Manager • Portfolio/Program Manager	
	Strategic Planning	• **Chief Executive Officer** • **Business Unit Manager** • **Project Sponsor**	• **Marketing Manager** • **Portfolio/Program Manager** • Finance Manager • Human Resource Manager • Information Technology Manager • Facility/Plant Manager • Operations/Production Manager	
	Market Analysis	• **Business Unit Manager** • Chief Executive Officer • Project Sponsor	• **Marketing/Sales Manager** • Finance Manager • Portfolio/Program Manager	
	Priority Setting	• **Chief Executive Officer** • **Business Unit Manager** • **Project Sponsor**	• **Finance Manager** • **Facility/Plant Manager** • **Operations/Production Manager** • **Portfolio/Program Manager** • Marketing/Sales Manager	• Engineering Manager • HSE Manager
	Opportunity Identification	• **Business Unit Manager** • **Project Sponsor** • Chief Executive Officer	• **Facility/Plant Manager** • **Operations/Production Manager** • Finance Manager • Marketing/Sales Manager • Portfolio/Program Manager	• Project Manager • Project Controls Manager • Engineering Manager • Engineering Team Lead
	Capital Budgeting	• **Business Unit Manager** • **Project Sponsor** • Chief Executive Officer	• **Accounting Manager** • **Finance Manager** • **Portfolio/Program Manager** • Facility/Plant Manager • Operations/Production Manager	• **Project Controls Manager** • Project Manager

Bold and underlined personnel are who are mainly involved in the work function

Phase	Work Function	Senior Management Personnel	Functional Management Personnel	Project Management Personnel
Feasibility Analysis	Financial Appraisal	• **Business Unit Manager** • Chief Executive Officer • Project Sponsor	• **Accounting Manager** • **Finance Manager** • Marketing/Sales Manager • Portfolio/Program Manager	• **Project Controls Manager** • Project Manager • Engineering Manager • Engineering Team Lead
	Economic Feasibility Analysis	• **Business Unit Manager** • Project Sponsor	• **Finance Manager** • Accounting Manager • Marketing/Sales Manager • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • Project Controls Manager • Engineering Manager • Engineering Team Lead
	Technical Feasibility Analysis	• **Project Sponsor** • Business Unit Manager	• **Operations/Production Manager** • Financial Manager • Information Technology Manager • Portfolio/Program Manager	• **Project Manager** • **Engineering Manager** • **Engineering Team Lead** • Project Controls Manager • QA/QC Manager
	Social Impact Analysis	• Business Unit Manager • Project Sponsor	• **Facility/Plant Manager** • Human Resource Manager • Contract/Legal Manager • Operations/Production Manager	• **Project Manager** • Engineering Manager • Engineering Team Leads • HSE Manager
	Environmental Impact Analysis	• Business Unit Manager • Project Sponsor	• **Facility/Plant Manager** • **Operations/Production Manager** • Contract/Legal Manager	• **HSE Manager** • Project Manager • Engineering Manager • Engineering Team Lead
Concept Development	Manufacturing Objectives Criteria	• **Business Unit Manager** • **Project Sponsor**	• **Facility/Plant Manager** • **Operations/Production Manager** • Marketing/Sales Manager • Portfolio/Program Manager	• **Project Manager** • Engineering Manager • HSE Manager
	Business Objectives	• **Business Unit Manager** • **Project Sponsor**	• Finance Manager • Marketing/Sales Manager • Facility/Plant Manager • Portfolio/Program Manager	• **Project Manager** • Engineering Manager • Engineering Team Lead
	Basic Data R&D	• Business Unit Manager • Project Sponsor	• Operations/Production Manager • Portfolio/Program Manager	• Project Manager • Engineering Manager • Engineering Team Lead

Phase	Work Function	Senior Management Personnel	Functional Management Personnel	Project Management Personnel
Concept Development	Project Scope	• **Business Unit Manager** • **Project Sponsor**	• **Facility/Plant Manager** • **Operations/Production Manager** • **Portfolio/Program Manager** • Marketing/Sales Manager • Information Technology Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Manager** • **Engineering Team Lead** • Procurement Manager • Construction Manager • QA/QC Manager • HSE Manager
	Value Engineering	• **Project Sponsor**	• **Operations/Production Manager** • Information Technology Manager • Facility/Plant Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Manager** • **Engineering Team Lead** • **Procurement Manager** • **Construction Manager** • QA/QC Manager • HSE Manager
Detailed Scope	Site Information	• Business Unit Manager • Project Sponsor	• **Operations/Production Manager** • **Portfolio/Program Manager** • Facility/Plant Manager	• **Project Manager** • **Engineering Manager** • **Engineering Team Lead** • **HSE Manager** • Project Controls Manager • Procurement Manager • Construction Manager • QA/QC Manager
	Procurement Strategy	• Project Sponsor	• **Contract/Legal Manager** • Facility/Plant Manager • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • **Procurement Manager** • Project Controls Manager • Engineering Manager • Engineering Team Lead • Construction Manager
	Project Execution Plan	• **Project Sponsor**	• **Operations/Production Manager** • **Portfolio/Program Manager** • Accounting Manager • Finance Manager • Human Resource Manager • Information Technology Manager • Facility/Plant Manager • Contract/Legal Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Manager** • **Engineering Team Lead** • **Procurement Manager** • **Construction Manager** • **QA/QC Manager** • **HSE Manager**

Phase	Work Function	Senior Management Personnel	Functional Management Personnel	Project Management Personnel
Project Execution	Project Management		• **Portfolio/Program Manager** • Accounting Manager • Finance Manager • Facility/Plant Manager • Operations/Production Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Manager** • Engineering Team Lead • Procurement Manager • Construction Manager • QA/QC Manager • HSE Manager
	Estimating	• Business Unit Manager • Project Sponsor	• Facility/Plant Manager • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Team Lead** • **Construction Manager** • Engineering Manager • Procurement Manager • QA/QC Manager
	Cost Management	• Business Unit Manager • Project Sponsor	• Facility/Plant Manager • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • Engineering Manager • Engineering Team Lead • Procurement Manager • Construction Manager
	Accounting		• **Accounting Manager** • Finance Manager	• **Project Manager** • **Project Controls Manager**
	Scheduling	• Business Unit Manager • Project Sponsor	• **Facility/Plant Manager** • **Operations/Production Manager** • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Manager** • **Engineering Team Lead** • Procurement Manager • Construction Manager • QA/QC Manager • HSE Manager
	Management Information System		• **Information Technology Manager** • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • QA/QC Manager

Phase	Work Function	Senior Management Personnel	Functional Management Personnel	Project Management Personnel
Project Execution	Communication	• **Business Unit Manager** • **Project Sponsor** • Chief Executive Officer	• **Facility/Plant Manager** • **Operations/Production Manager** • **Portfolio/Program Manager** • Accounting Manager • Finance Manager • Marketing/Sales Manager • Human Resource Manager • Information Technology Manager • Contract/Legal Manager	• **Project Manager** • **Project Controls Manager** • **Construction Manager** • Engineering Manager • Engineering Team Lead • Procurement Manager • QA/QC Manager • HSE Manager
	Risk Management	• Business Unit Manager • Project Sponsor	• Marketing/Sales Manager • Contract/Legal Manager • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Manager** • **Procurement Manager** • **Construction Manager** • **HSE Manager** • Engineering Team Lead • QA/QC Manager
	Contracting		• **Contract/Legal Manager** • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Manager** • **Procurement Manager** • **Construction Manager** • Engineering Team Lead
	Permitting	• Project Sponsor	• **Contract/Legal Manager** • Facility/Plant Manager • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • **Engineering Manager** • **HSE Manager** • Project Controls Manager • Engineering Team Lead • Construction Manager
	Funding Requests	• **Chief Executive Officer** • **Business Unit Manager** • **Project Sponsor**	• **Accounting Manager** • **Finance Manager** • **Facility/Plant Manager** • **Portfolio/Program Manager** • Operations/Production Manager	• **Project Manager** • **Project Controls Manager** • Engineering Manager • Engineering Manager • QA/QC Manager • HSE Manager

Phase	Work Function	Senior Management Personnel	Functional Management Personnel	Project Management Personnel
Project Execution	Change Management	• Business Unit Manager • Project Sponsor	• **Operations/Production Manager** • Facility/Plant Manager • Contract/Legal Manager • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Team Lead** • **Procurement Manager** • **Construction Manager** • **QA/QC Manager** • HSE Manager
	Health/Safety /Environment (HSE)		• Facility/Plant Manager • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • **Engineering Manager** • **HSE Manager** • Engineering Team Lead • Construction Manager
	Claims Management		• Contract/Legal Manager • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • **Procurement Manager** • Engineering Manager • Engineering Team Lead • Construction Manager • QA/QC Manager
	Quality Assurance /Quality Control (QA/QC)		• Facility/Plant Manager • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • **Engineering Manager** • **Engineering Team Lead** • **QA/QC Manager** • Project Controls Manager • Procurement Manager • Construction Manager
	Human Resource Management	• Project Sponsor	• **Human Resource Manager** • Facility/Plant Manager • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Manager** • **Engineering Team Lead** • **Procurement Manager** • **Construction Manager**
	Detailed Engineering	• Project Sponsor	• **Operations/Production Manager** • Facility/Plant Manager • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Manager** • **Engineering Team Lead** • **Procurement Manager** • **Construction Manager**

Phase	Work Function	Senior Management Personnel	Functional Management Personnel	Project Management Personnel
Project Execution	Procurement		• Accounting Manager • Facility/Plant Manager • Contract/Legal Manager • Operations/Production Manager • Portfolio/Program Manager	• **Project Manager** • **Engineering Team Lead** • **Procurement Manager** • Project Controls Manager • Engineering Manager • Construction Manager • QA/QC Manager • HSE Manager
	Construction		• **Operations/Production Manager** • Facility/Plant Manager • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Team Lead** • **Construction Manager** • Engineering Manager • Procurement Manager • QA/QC Manager • HSE Manager
	Startup /Commissioning		• **Facility/Plant Manager** • **Operations/Production Manager** • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Manager** • **Engineering Team Lead** • **Construction Manager** • **QA/QC Manager** • **HSE Manager** • Procurement Manager
Project Close-out		• Business Unit Manager • Project Sponsor	• **Accounting Manager** • **Operations/Production Manager** • Facility/Plant Manager • Finance Manager • Marketing/Sales Manager • Information Technology Manager • Contract/Legal Manager • Portfolio/Program Manager	• **Project Manager** • **Project Controls Manager** • **Engineering Team Lead** • **Construction Manager** • **QA/QC Manager** • **HSE Manager** • Engineering Manager • Procurement Manager

APPENDIX C: CORRELATIONS BETWEEN PI AND TI

Somers' *d* Coefficient between Personnel Involvement and Task Interaction (Project Size: All)

Management Personnel		Business Planning						Feasibility Analysis				
		Corporate Goal Setting	Strategic Planning	Market Analysis	Priority Setting	Opportunity Identification	Capital Budgeting	Financial Appraisal	Economic Feasibility	Technical Feasibility	Social Impact Analysis	Environmental Impact Analysis
Senior Management Personnel	Chief Executive Officer	-0.231	-0.087	-0.115	-0.185	0.114	**0.294	-0.169				
	Business Unit Manager	0.010	-0.209	0.000	-0.115	**0.299	0.027	-0.338	-0.187	0.158	-0.074	-0.080
	Project Sponsor	-0.405	0.072	0.097	-0.145	-0.315	0.173	-0.018	-0.183	-0.007	-0.449	-0.084
Functional Management Personnel	Accounting Manager						0.154	-0.248	0.048			
	Finance Manager	-0.229	0.197	0.006	0.173	-0.329	0.029	-0.201	0.163	-0.002		
	Marketing/Sales Manager	0.056	-0.235	-0.198	**0.289	*0.269		-0.108	**0.447			
	Human Resource Manager	-0.287	0.164								-0.446	
	Information Technology Manager		0.150							-0.330		
	Facility/Plant Manager		0.017		-0.056	-0.317	-0.153			-0.260	-0.591	-0.332
	Contract/Legal Manager										0.150	0.135
	Operations/Production Manager		**0.358	**0.407	0.154	0.184	**0.490		0.031	0.149	-0.203	0.007
	Portfolio/Program Manager	-0.060	-0.064	-0.391	0.019	0.120	0.221	0.000	0.093	-0.096		
Project Management Personnel	Project Manager					-0.367	0.062	-0.012	-0.306	-0.218	-0.660	-0.266
	Project Controls Manager					-0.301	0.000	-0.470	-0.159	-0.222		
	Engineering Manager				-0.216	-0.411		-0.238	-0.255	-0.356	-0.645	-0.323
	Engineering Team Leads					-0.293		-0.480	-0.245	-0.156	-0.421	-0.306
	Procurement Manager											
	Construction Manager											
	QA/QC Manager									0.176		
	HSE Manager				**0.475						0.175	0.035

** indicates *p*-value is lower than 0.05. * indicates *p*-value is lower than 0.1
Sample size for each correlation range from 20 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

Somers' d Coefficient between Personnel Involvement and Task Interaction (Project Size: All) (Continued)

Management Personnel		Concept Development					Detailed Scope		
		Manufacturing Objective Criteria	Business Objectives	Basic Data R&D	Project Scope	Value Engineering	Site Information	Procurement Strategy	Project Execution Plan
Senior Management Personnel	Chief Executive Officer								
	Business Unit Manager	0.133	**0.286	**0.636	0.233		**0.362	*0.249	**0.349
	Project Sponsor	0.091	0.143	-0.206	-0.135	0.059	0.017	-0.376	-0.048
Functional Management Personnel	Accounting Manager							-0.180	0.059
	Finance Manager								-0.288
	Marketing/Sales Manager	0.134	0.097		*0.264				
	Human Resource Manager								-0.149
	Information Technology Manager				-0.016	-0.097			-0.269
	Facility/Plant Manager	0.003	0.093		-0.193	0.039	-0.054	-0.175	-0.023
	Contract/Legal Manager							0.035	0.138
	Operations/Production Manager	-0.044	0.082	-0.379	-0.047	-0.022	0.072	-0.104	0.077
	Portfolio/Program Manager	0.087	0.160	0.078	0.116		-0.366	-0.261	-0.385
Project Management Personnel	Project Manager	0.086	0.190	-0.242	0.000	**0.423	**0.414	-0.087	**0.372
	Project Controls Manager		-0.272		-0.383	-0.400	-0.487	-0.387	-0.286
	Engineering Manager	-0.116	-0.002	-0.464	-0.261	-0.336	-0.336	-0.498	-0.275
	Engineering Team Leads		-0.131	-0.483	-0.269	-0.240	-0.415	-0.489	-0.233
	Procurement Manager				-0.333	-0.242	-0.193	-0.465	-0.254
	Construction Manager				-0.091	-0.045	0.012	-0.010	0.196
	QA/QC Manager				-0.234	-0.165	-0.141		0.040
	HSE Manager				-0.183	-0.205	-0.225		-0.023

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Sample size for each correlation range from 13 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

Somers' d Coefficient between Personnel Involvement and Task Interaction (Project Size: All) (Continued)

Management Personnel		Project Execution									
		Project Management	Estimating	Cost Management	Accounting	Scheduling	Communication	Management Information System	Risk Management	Contracting	Permitting
Senior Management Personnel	Chief Executive Officer						0.115				0.103
	Business Unit Manager		0.099	0.197		*0.269	**0.473		*0.288		**0.345
	Project Sponsor		-0.166	0.020		-0.286	0.111		0.198		-0.135
Functional Management Personnel	Accounting Manager	0.041			-0.107		0.074				
	Finance Manager	-0.210			-0.095		-0.112				
	Marketing/Sales Manager						0.063		-0.111		
	Human Resource Manager						-0.025				
	Information Technology Manager						0.045	-0.302			
	Facility/Plant Manager	0.169	-0.058	-0.157		-0.069	0.161			-0.360	-0.016
	Contract/Legal Manager						-0.151		**0.393	0.190	0.118
	Operations/Production Manager	-0.017	0.117	0.214		-0.040	-0.056		*0.283	0.114	0.136
	Portfolio/Program Manager	-0.228	-0.331	-0.270		-0.172	0.054	-0.190	-0.082	-0.390	-0.367
Project Management Personnel	Project Manager	**0.392	**0.362	*0.262	-0.253	-0.201	0.174	0.061	**0.401	-0.083	**0.331
	Project Controls Manager	-0.175	-0.279	-0.424	-0.279	-0.324	-0.190	-0.097	*0.283	-0.270	-0.051
	Engineering Manager	-0.068	-0.259	-0.302		-0.447	-0.081		0.079	-0.472	-0.220
	Engineering Team Leads	-0.110	-0.242	-0.272		-0.273	-0.043		**0.307	-0.328	
	Procurement Manager	-0.002	-0.164	-0.240		-0.405	-0.094		0.154	-0.398	-0.128
	Construction Manager	0.170	**0.308	0.034		-0.191	-0.162		**0.535	*0.291	**0.533
	QA/QC Manager	0.004	-0.008			-0.141	-0.129	**0.346	**0.395		
	HSE Manager	-0.100				-0.100	-0.132		**0.497		0.224

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Sample size for each correlation range from 20 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

Somers' d Coefficient between Personnel Involvement and Task Interaction (Project Size: All) (Continued)

Management Personnel		Project Execution										
		Funding Requests	Change Management	Health, Safety, and Environment (HSE)	Claims Management	Quality Assurance/ Quality Controls	Human Resource Management	Detailed Engineering	Procurement	Construction	Startup/Commissioning	Project Close-out
Senior Management Personnel	Chief Executive Officer	-0.085										
	Business Unit Manager	*0.276	*0.249									**0.325
	Project Sponsor	0.242	0.134				0.279	-0.134	-0.137			-0.259
Functional Management Personnel	Accounting Manager	**0.322								0.000		0.082
	Finance Manager	0.169										-0.202
	Marketing/Sales Manager											
	Human Resource Manager						**0.453					
	Information Technology Manager											-0.507
	Facility/Plant Manager	**0.350	0.171	**0.346		-0.028	0.112	-0.029	-0.064	-0.014	0.214	-0.125
	Contract/Legal Manager		0.211		0.048			-0.076	0.167			**0.310
	Operations/Production Manager	0.183	0.071	-0.173	-0.072	*0.286	*0.323	-0.083	*0.249	0.190	*0.255	0.254
	Portfolio/Program Manager	0.013	-0.389	-0.025	0.015	-0.419	0.290	-0.377	-0.426	-0.295	-0.288	-0.253
Project Management Personnel	Project Manager	0.082	*0.223	-0.079	-0.184	0.145	-0.018	*0.244	0.235	**0.317	**0.401	*0.236
	Project Controls Manager	0.083	-0.214		-0.533	-0.174	0.134	-0.503	-0.050	-0.140	0.115	-0.041
	Engineering Manager	0.009	-0.189	0.049	-0.614	-0.333	0.015	-0.400	-0.225	-0.147	-0.092	-0.304
	Engineering Team Leads		-0.089	0.009	-0.533	-0.110	0.184	-0.402	-0.080	-0.170	0.179	0.007
	Procurement Manager		-0.039		-0.488	-0.229	0.199	-0.384	-0.103	-0.113	0.061	-0.121
	Construction Manager		-0.098	-0.101	0.077	0.047	0.285	-0.116	**0.382	**0.360	**0.313	**0.469
	QA/QC Manager	0.087	0.092		-0.100	0.227		-0.239	0.180	0.098	0.213	-0.006
	HSE Manager	0.121	0.014	0.164				-0.213	0.158	0.128	*0.241	0.215

** indicates exact *p*-value is lower than 0.05. * indicates exact *p*-value is lower than 0.1
Sample size for each correlation range from 20 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

Somers' d Coefficient between Personnel Involvement and Task Interaction (Project Size: $5MM ~ $50MM)

Management Personnel		Business Planning						Feasibility Analysis				
		Corporate Goal Setting	Strategic Planning	Market Analysis	Priority Setting	Opportunity Identification	Capital Budgeting	Financial Appraisal	Economic Feasibility	Technical Feasibility	Social Impact Analysis	Environmental Impact Analysis
Senior Management Personnel	Chief Executive Officer	-0.303	-0.319	-0.232	-0.301	0.000	0.239	-0.324				
	Business Unit Manager	-0.148	-0.363	-0.351	-0.463	0.275	0.079	-0.523	-0.589	0.045	-0.242	-0.446
	Project Sponsor	-0.613	-0.396	-0.198	-0.160	-0.241	0.064	-0.214	0.183	0.246	0.242	0.035
Functional Management Personnel	Accounting Manager						0.068	-0.470	0.323			
	Finance Manager	-0.198	0.000	-0.034	0.108	-0.381	-0.137	-0.362	0.175	-0.030		
	Marketing/Sales Manager	-0.169	-0.177	-0.232	-0.168	-0.198		-0.324	0.131			
	Human Resource Manager	-0.169	0.113								-0.348	
	Information Technology Manager		-0.295							-0.162		
	Facility/Plant Manager		-0.158		-0.119	-0.365	-0.355			-0.335	N.A.	-0.585
	Contract/Legal Manager										0.774	0.359
	Operations/Production Manager		**0.465	0.327	0.289	0.271	**0.508		**0.554	0.333	0.242	0.287
	Portfolio/Program Manager	-0.201	-0.054	-0.653	-0.400	-0.151	0.211	-0.351	-0.250	3.027		
Project Management Personnel	Project Manager					N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Project Controls Manager					-0.312	-0.134	-0.519	0.118	-0.073		
	Engineering Manager				-0.179	-0.357		-0.321	-0.171	-0.289	0.000	-0.300
	Engineering Team Leads					-0.305		-0.660	0.051	0.030	0.571	-0.201
	Procurement Manager											
	Construction Manager											
	QA/QC Manager									0.294		
	HSE Manager				**0.605						0.571	0.010

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Sample size for each correlation range from 20 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

Somers' d Coefficient between Personnel Involvement and Task Interaction (Project Size: $5MM ~ $50MM)

Management Personnel		Concept Development					Detailed Scope		
		Manufacturing Objective Criteria	Business Objectives	Basic Data R&D	Project Scope	Value Engineering	Site Information	Procurement Strategy	Project Execution Plan
Senior Management Personnel	Chief Executive Officer								
	Business Unit Manager	-0.047	0.318	0.000	0.173	0.129	0.178	-0.276	-0.126
	Project Sponsor	0.070	-0.022	0.000	-0.244	-0.067	-0.253	-0.419	-0.357
Functional Management Personnel	Accounting Manager							-0.365	-0.436
	Finance Manager							-0.300	-0.468
	Marketing/Sales Manager	0.114	0.000		0.154				
	Human Resource Manager								-0.239
	Information Technology Manager				0.141	0.079			-0.284
	Facility/Plant Manager	-0.225	-0.045		-0.471	-0.382	-0.649	-0.296	-0.492
	Contract/Legal Manager							-0.108	-0.178
	Operations/Production Manager	-0.364	-0.277	-0.800	-0.048	-0.370	-0.273	-0.098	-0.022
	Portfolio/Program Manager	-0.071	0.301	-0.138	0.234		-0.233	-0.305	-0.418
Project Management Personnel	Project Manager	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Project Controls Manager				-0.517	-0.559	-0.867	-0.315	-0.461
	Engineering Manager	-0.228	-0.031	0.083	-0.344	-0.433	-0.588	-0.322	-0.583
	Engineering Team Leads		-0.251	-0.600	-0.306	-0.320	-0.836	-0.554	-0.551
	Procurement Manager				-0.341	-0.547	-0.615	-0.208	-0.486
	Construction Manager				-0.151	-0.383	-0.350	0.225	0.140
	QA/QC Manager				-0.497	-0.416	-0.338		0.000
	HSE Manager				-0.316	-0.515	-0.452		0.010

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Sample size for each correlation range from 13 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

Somers' d Coefficient between Personnel Involvement and Task Interaction (Project Size: $5MM ~ $50MM)

Management Personnel		Project Execution									
		Project Management	Estimating	Cost Management	Accounting	Scheduling	Communication	Management Information System	Risk Management	Contracting	Permitting
Senior Management Personnel	Chief Executive Officer						0.185				
	Business Unit Manager		-0.420	0.066		-0.034	**0.586		0.230		-0.194
	Project Sponsor		-0.545	-0.010		0.000	-0.065		0.016		-0.503
Functional Management Personnel	Accounting Manager	-0.459			-0.365		-0.279				
	Finance Manager	-0.343			-0.211		-0.300				
	Marketing/Sales Manager						0.017		0.049		
	Human Resource Manager						0.017				
	Information Technology Manager						0.198	-0.342			
	Facility/Plant Manager	-0.151	-0.487	-0.579		-0.239	-0.110			-0.390	-0.462
	Contract/Legal Manager						-0.592		0.242	0.177	0.035
	Operations/Production Manager	-0.586	-0.152	-0.022		-0.257	-0.294		N.A.	0.347	0.190
	Portfolio/Program Manager	-0.099	-0.098	-0.145		-0.264	0.166	-0.113	0.295	-0.415	-0.464
Project Management Personnel	Project Manager	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Project Controls Manager	-0.402	-0.406	-0.535	-0.070	-0.406	-0.316	0.118	**0.515	-0.095	-0.088
	Engineering Manager	-0.208	-0.371	-0.388		-0.370	-0.121		0.080	-0.430	-0.508
	Engineering Team Leads	-0.412	-0.495	-0.414		-0.396	-0.123		**0.500	-0.322	
	Procurement Manager	-0.089	-0.230	-0.380		-0.360	-0.159		0.179	-0.094	-0.251
	Construction Manager	-0.103	0.337	-0.112		-0.058	-0.398		**0.538	**0.545	**0.593
	QA/QC Manager	-0.312	-0.058			-0.010	-0.468	**0.556	*0.449		
	HSE Manager	-0.272				-0.029	-0.267		**0.576		0.352

** indicates *p*-value is lower than 0.05. * indicates *p*-value is lower than 0.1
Sample size for each correlation range from 20 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

Somers' d Coefficient between Personnel Involvement and Task Interaction (Project Size: $5MM ~ $50MM)

Management Personnel		Project Execution										
		Funding Requests	Change Management	Health, Safety, and Environment (HSE)	Claims Management	Quality Assurance/ Quality Controls	Human Resource Management	Detailed Engineering	Procurement	Construction	Startup/Commissioning	Project Close-out
Senior Management Personnel	Chief Executive Officer	0.195										
	Business Unit Manager	0.333	0.000									0.034
	Project Sponsor	*0.426	-0.023				0.538	-0.219				-0.613
Functional Management Personnel	Accounting Manager	*0.431							-0.254	-0.211		-0.128
	Finance Manager	*0.421										-0.198
	Marketing/Sales Manager											
	Human Resource Manager						0.538					
	Information Technology Manager											-0.761
	Facility/Plant Manager	**0.478	0.241	0.321		-0.029	N.A.	-0.411	-0.382	-0.333	-0.064	-0.435
	Contract/Legal Manager		-0.070		-0.205				0.114			0.088
	Operations/Production Manager	-0.248	-0.473	-0.110	0.022	0.292	**0.833	N.A.	0.231	-0.057	0.284	0.112
	Portfolio/Program Manager	0.294	-0.309	-0.210	-0.250	-0.436	0.063	-0.364	-0.471	-0.129	-0.282	0.050
Project Management Personnel	Project Manager	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Project Controls Manager	0.352	0.022	0.062	-0.040	0.000	**0.833	-0.636	-0.118	-0.223	0.255	0.042
	Engineering Manager	**0.453	0.063	0.167	-0.653	-0.189	0.129	-0.515	-0.454	-0.265	-0.118	-0.360
	Engineering Team Leads		-0.021	-0.040	-0.400	0.110	**0.833	-0.591	-0.325	-0.415	0.308	-0.020
	Procurement Manager		0.083		-0.413	-0.198	0.538	-0.543	-0.140	-0.103	0.022	-0.045
	Construction Manager		-0.147	-0.159	**0.585	0.095	**0.833	-0.391	**0.467	0.343	0.215	**0.694
	QA/QC Manager	-0.026	0.114		-0.019	*0.440		-0.268	0.294	0.000	0.300	0.039
	HSE Manager	-0.091	-0.021	0.184				-0.333	0.343	0.160	0.308	N.A.

** indicates *p*-value is lower than 0.05. * indicates *p*-value is lower than 0.1
Sample size for each correlation range from 20 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

Somers' d Coefficient between Personnel Involvement and Task Interaction (Project Size: > $50MM)

Management Personnel		Business Planning						Feasibility Analysis				
		Corporate Goal Setting	Strategic Planning	Market Analysis	Priority Setting	Opportunity Identification	Capital Budgeting	Financial Appraisal	Economic Feasibility	Technical Feasibility	Social Impact Analysis	Environmental Impact Analysis
Senior Management Personnel	Chief Executive Officer	-0.021	0.220	0.055	0.170	0.339	0.260	0.097				
	Business Unit Manager	0.145	-0.108	0.168	0.191	0.343	-0.123	-0.256	-0.145	0.290	0.000	0.159
	Project Sponsor	-0.117	0.111	-0.040	0.197	-0.092	0.317	0.248	-0.250	0.104	-0.216	0.150
Functional Management Personnel	Accounting Manager						0.200	-0.060	0.094			
	Finance Manager	-0.230	0.250	-0.097	0.358	-0.253	0.297	-0.107	0.327	0.118		
	Marketing/Sales Manager	-0.167	0.282	0.290	0.214	0.339		-0.296	0.185			
	Human Resource Manager	-0.236	0.224								-0.421	
	Information Technology Manager		0.343							-0.167		0.087
	Facility/Plant Manager		-0.075		0.271	-0.162	-0.015			-0.014	-0.216	-0.120
	Contract/Legal Manager										0.500	0.148
	Operations/Production Manager		0.191	0.306	*0.394	0.364	*0.456		-0.018	0.347	0.000	0.122
	Portfolio/Program Manager	-0.101	0.457	0.140	0.360	0.200	0.400	-0.205	0.145	-0.035		
Project Management Personnel	Project Manager					N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Project Controls Manager					-0.182	-0.130	-0.414	-0.071	-0.172		
	Engineering Manager				0.032	-0.180		-0.098	0.059	-0.172	-0.471	-0.192
	Engineering Team Leads					-0.154		-0.269	-0.316	-0.037	N.A.	-0.354
	Procurement Manager											
	Construction Manager											
	QA/QC Manager									0.324		
	HSE Manager				*0.456						*0.649	0.147

** indicates *p*-value is lower than 0.05. * indicates *p*-value is lower than 0.1
Sample size for each correlation range from 20 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

Somers' d Coefficient between Personnel Involvement and Task Interaction (Project Size: > $50MM)

Management Personnel		Concept Development					Detailed Scope		
		Manufacturing Objective Criteria	Business Objectives	Basic Data R&D	Project Scope	Value Engineering	Site Information	Procurement Strategy	Project Execution Plan
Senior Management Personnel	Chief Executive Officer								
	Business Unit Manager	0.224	0.193	**0.970	0.290		**0.536		
	Project Sponsor	0.109	0.164	-0.071	0.000	-0.246	-0.239	-0.354	-0.246
Functional Management Personnel	Accounting Manager							0.075	0.119
	Finance Manager								-0.379
	Marketing/Sales Manager	0.169	0.000		0.194				
	Human Resource Manager								-0.083
	Information Technology Manager				0.031	-0.415		-0.507	-0.594
	Facility/Plant Manager	0.250	0.211		0.125	0.277	0.155	0.087	0.116
	Contract/Legal Manager			0.129				0.172	0.094
	Operations/Production Manager	0.305	0.375	-0.059	0.108	-0.030	0.125	-0.014	0.057
	Portfolio/Program Manager	0.404	0.301	-0.074	0.061	-0.396	-0.248	-0.422	-0.202
Project Management Personnel	Project Manager	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Project Controls Manager				-0.255	-0.423	-0.500	-0.571	-0.339
	Engineering Manager	0.093	0.188	-0.596	-0.053	-0.793	-0.734	-0.839	-0.532
	Engineering Team Leads		0.147	N.A.	-0.105	-0.247	-0.330	-0.400	-0.171
	Procurement Manager				-0.203	-0.467	-0.273	-0.594	-0.484
	Construction Manager				N.A.	N.A.	N.A.	N.A.	N.A.
	QA/QC Manager				-0.156	-0.308	-0.338		-0.087
	HSE Manager				-0.314	-0.192	-0.345		-0.196

** indicates *p*-value is lower than 0.05. * indicates *p*-value is lower than 0.1
Sample size for each correlation range from 13 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

Somers' d Coefficient between Personnel Involvement and Task Interaction (Project Size: > $50MM)

Management Personnel		Project Execution									
		Project Management	Estimating	Cost Management	Accounting	Scheduling	Communication	Management Information System	Risk Management	Contracting	Permitting
Senior Management Personnel	Chief Executive Officer						0.321				
	Business Unit Manager		**0.471	*0.438		**0.511	0.338		*0.415		**0.912
	Project Sponsor		-0.288	-0.258		-0.078	0.227		0.031		-0.227
Functional Management Personnel	Accounting Manager	0.118			0.305		0.250				
	Finance Manager	-0.313			-0.016		0.045				
	Marketing/Sales Manager						0.143		0.120		
	Human Resource Manager						0.180				
	Information Technology Manager						0.043	-0.206			
	Facility/Plant Manager	0.286	0.086	0.106		0.292	**0.514			-0.063	0.157
	Contract/Legal Manager						0.031		*0.419	0.388	0.062
	Operations/Production Manager	0.211	0.197	0.299		0.360	0.133		0.199	0.085	-0.085
	Portfolio/Program Manager	-0.018	-0.378	-0.252		-0.391	0.126	-0.247	0.036	-0.643	-0.108
Project Management Personnel	Project Manager	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Project Controls Manager	-0.158	-0.404	-0.415	-0.404	-0.198	0.088	-0.460	0.035	-0.516	-0.456
	Engineering Manager	-0.349	-0.683	-0.508		-0.569	0.048		-0.160	-0.586	-0.571
	Engineering Team Leads	0.037	-0.243	-0.182		0.019	0.318		0.226	-0.271	
	Procurement Manager	-0.262	-0.462	-0.393		-0.268	0.000		-0.140	-0.618	-0.462
	Construction Manager	N.A.	N.A.	N.A.		N.A.	N.A.		N.A.	N.A.	N.A.
	QA/QC Manager	-0.043	-0.314			-0.131	0.057	0.095	0.129		
	HSE Manager	-0.298				-0.090	0.000		0.212		-0.228

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Sample size for each correlation range from 20 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

Somers' d Coefficient between Personnel Involvement and Task Interaction (Project Size: > $50MM)

Management Personnel		Project Execution										
		Funding Requests	Change Management	Health, Safety, and Environment (HSE)	Claims Management	Quality Assurance/ Quality Controls	Human Resource Management	Detailed Engineering	Procurement	Construction	Startup/Commissioning	Project Close-out
Senior Management Personnel	Chief Executive Officer	-0.120										
	Business Unit Manager	0.046	0.000									**0.597
	Project Sponsor	0.238	0.108				*0.523	-0.444				-0.267
Functional Management Personnel	Accounting Manager	0.215							0.197			0.097
	Finance Manager	0.09 4										-0.262
	Marketing/Sales Manager											-0.167
	Human Resource Manager						**0.636					
	Information Technology Manager											
	Facility/Plant Manager	*0.433	0.261	**0.638		0.120	0.282	0.194	0.132	0.149	**0.469	0.125
	Contract/Legal Manager		0.203		0.381				0.111			0.373
	Operations/Production Manager	**0.635	*0.400	-0.029	0.036	0.281	0.438	-0.103	0.043	0.235	0.054	0.138
	Portfolio/Program Manager	-0.133	-0.349	0.128	-0.048	-0.385	**0.593	-0.248	-0.299	-0.267	-0.034	-0.485
Project Management Personnel	Project Manager	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Project Controls Manager	0.148	-0.054	0.143	-0.635	-0.262	-0.128	-0.574	-0.382	-0.352	0.016	-0.412
	Engineering Manager	-0.167	-0.500	0.032	-0.495	-0.555	0.159	-0.733	-0.574	-0.500	-0.458	-0.719
	Engineering Team Leads		0.152	0.000	-0.526	-0.060	N.A.	-0.416	-0.155	-0.139	0.071	-0.189
	Procurement Manager		-0.094		-0.453	-0.309	0.492	-0.597	-0.476	-0.452	-0.193	-0.593
	Construction Manager		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	QA/QC Manager	0.164	0.130		-0.055	-0.060		-0.463	-0.044	-0.343	0.014	0.000
	HSE Manager	0.296	0.143	0.036				-0.185	-0.200	-0.222	0.017	-0.039

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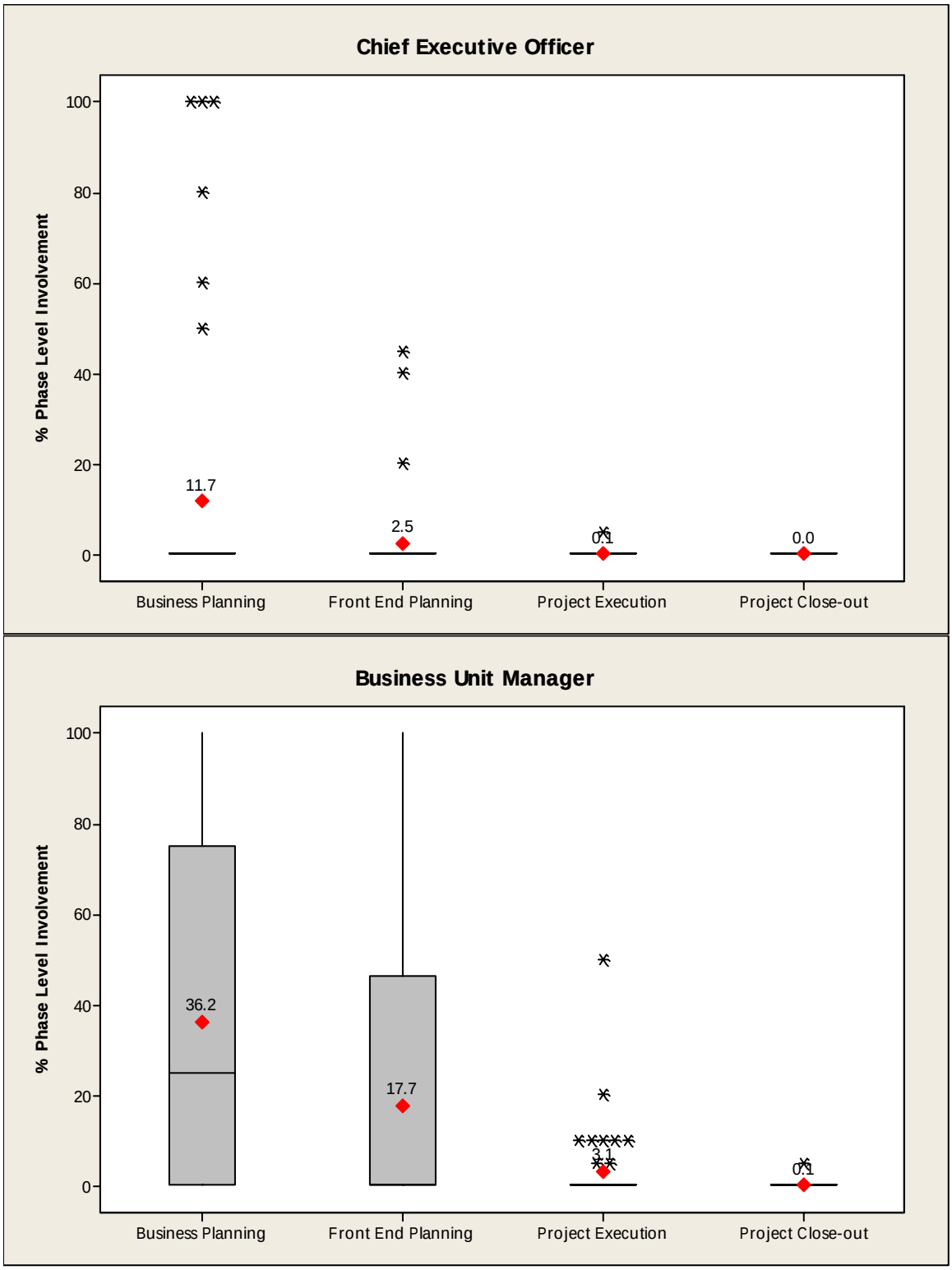
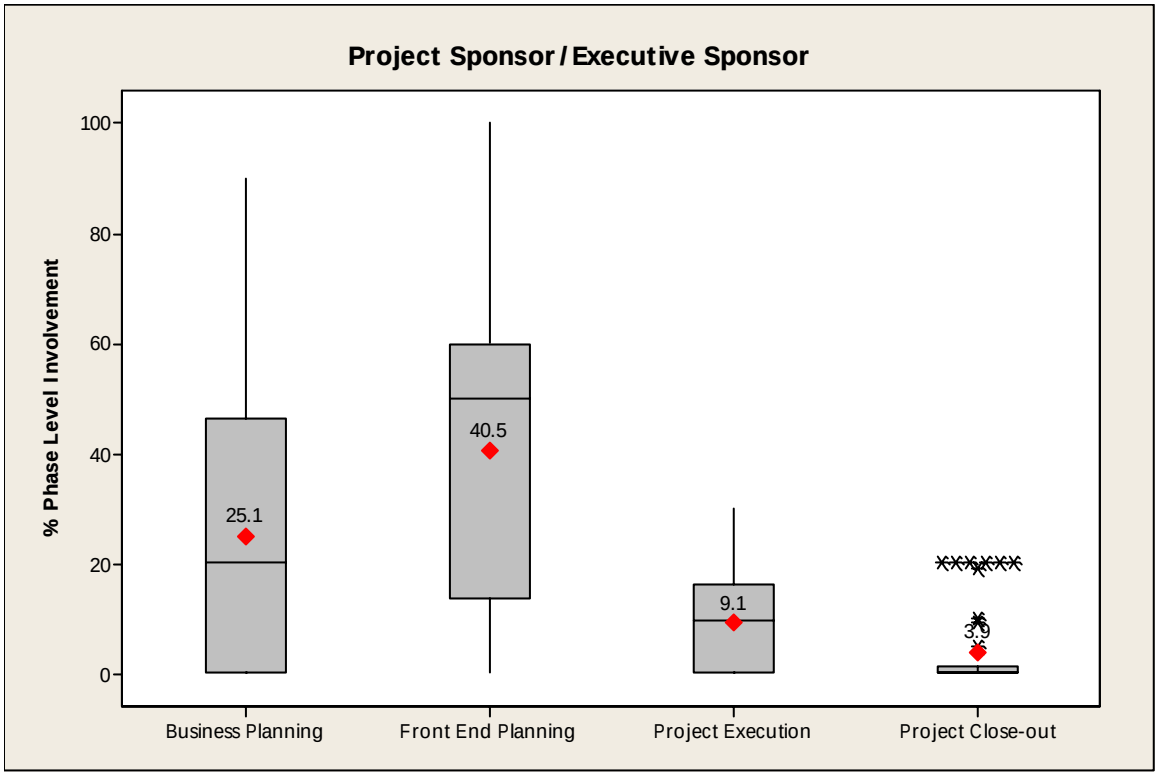
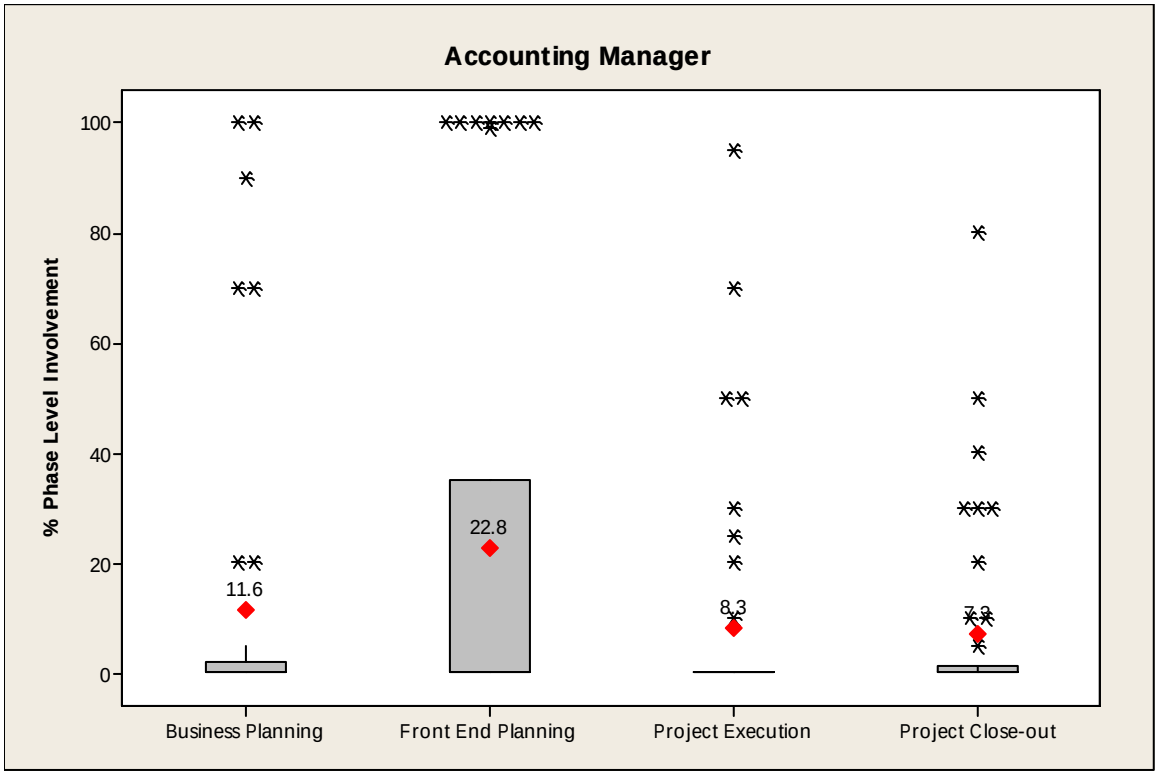
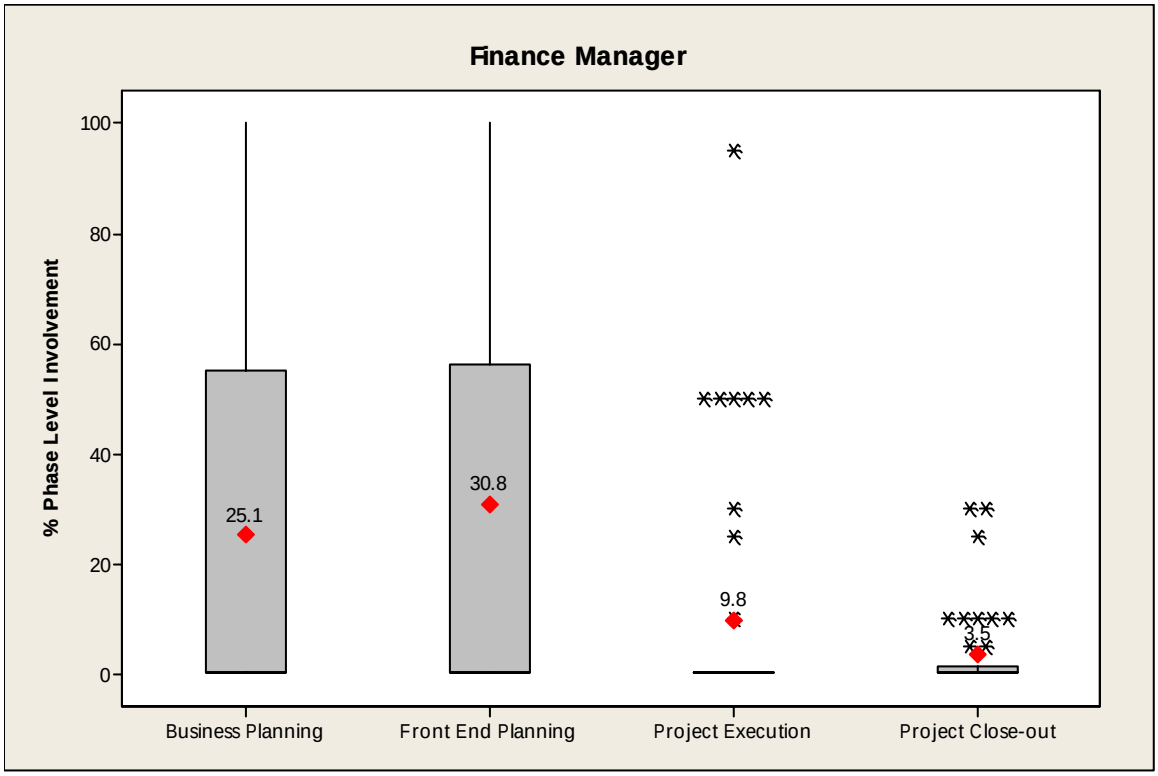
Sample size for each correlation range from 20 to 42
C.T. Data withheld per CII Confidential Policy (less than 10 projects or data submitted by less than 3 companies)

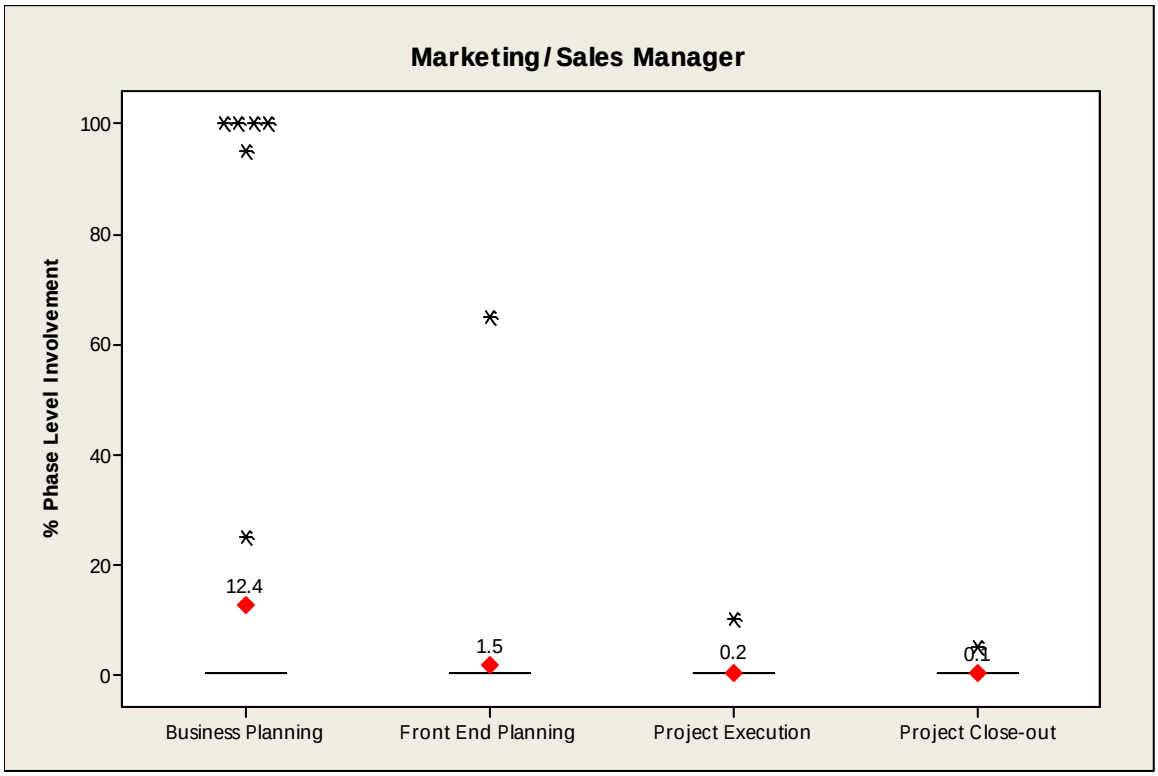
APPENDIX D: BOX-PLOT OF % PHASE LEVEL INVOLVEMENT

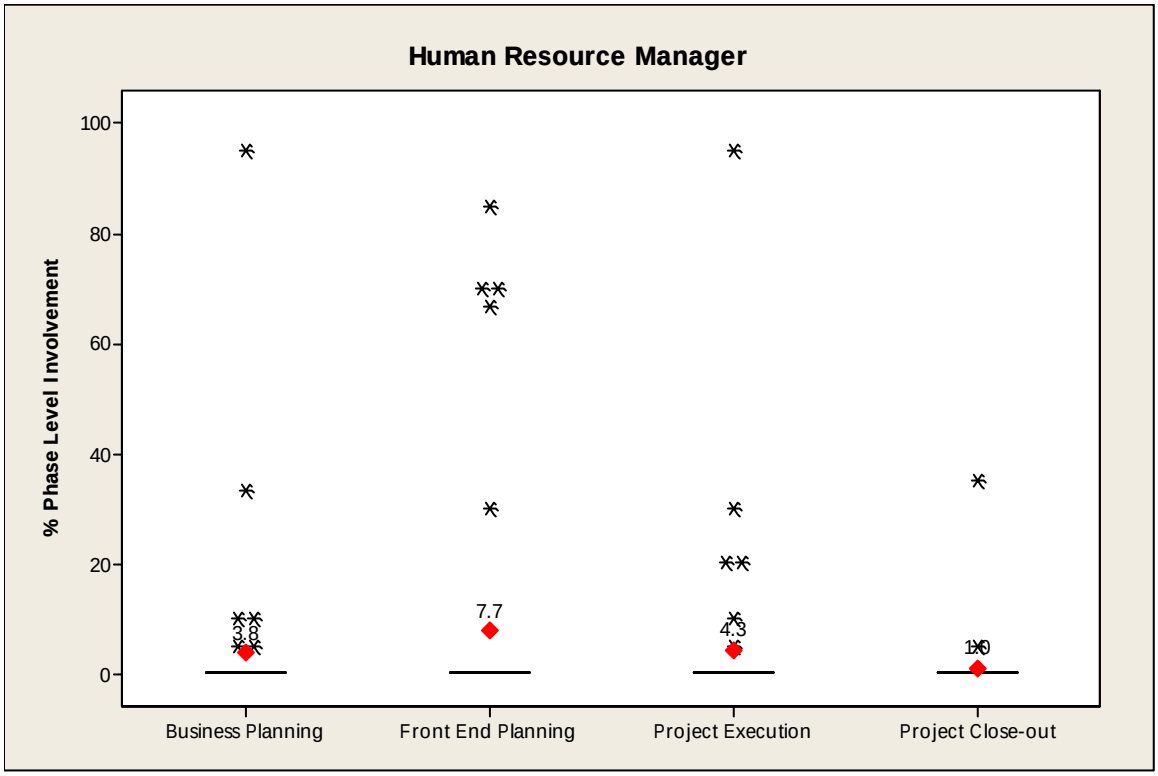


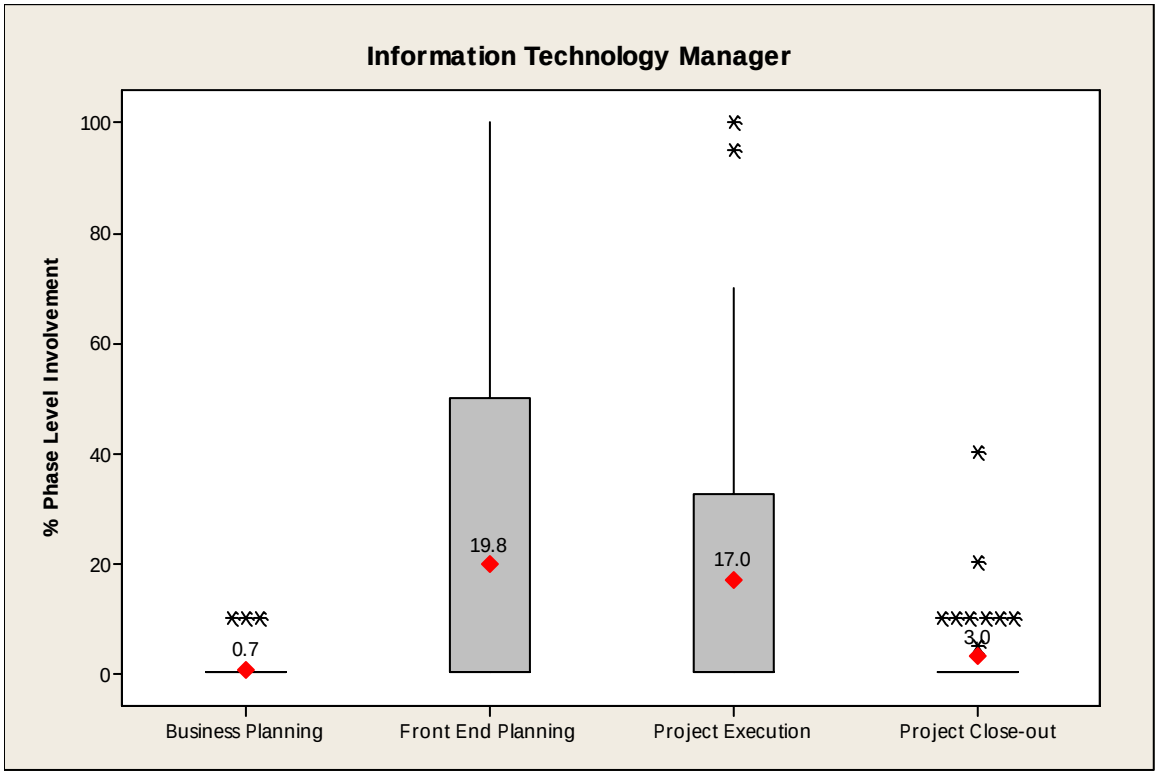

Project Sponsor / Executive Sponsor
% Phase Level Involvement
100
80
60
40
20
0
25.1
40.5
9.1
3.9
Business Planning
Front End Planning
Project Execution
Project Close-out

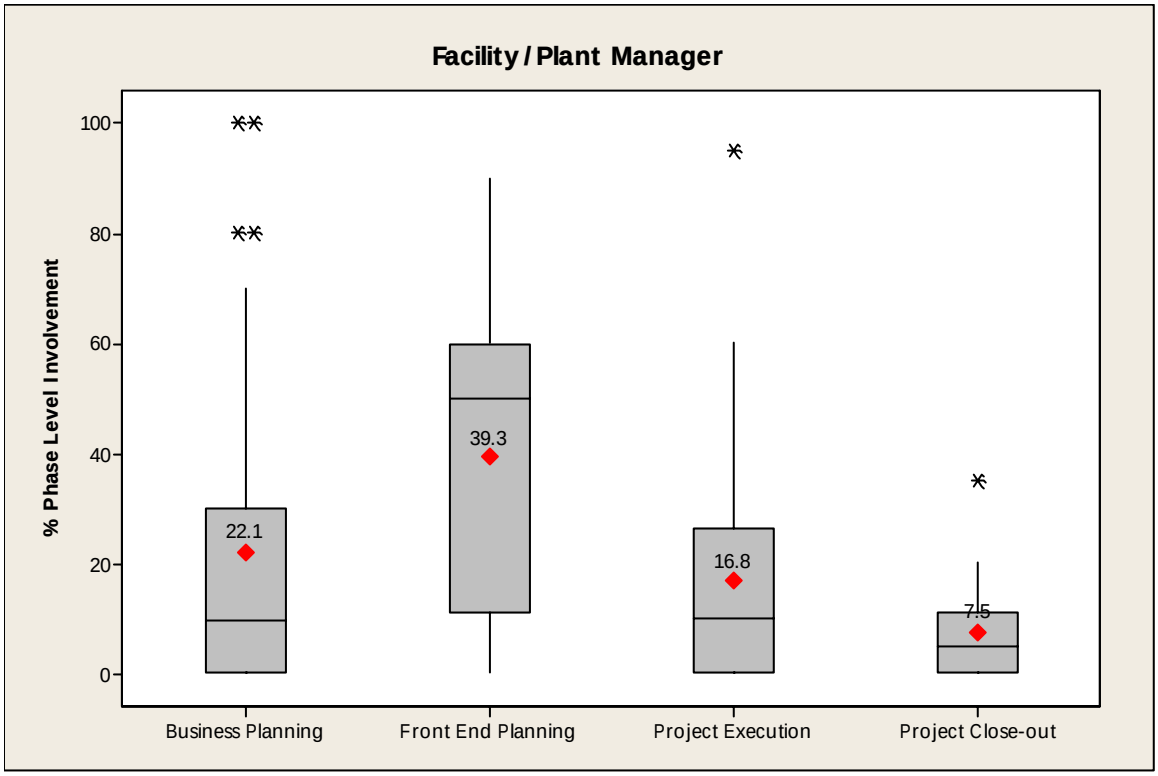

Accounting Manager
% Phase Level Involvement
100
80
60
40
20
0
11.6
22.8
8.3
Business Planning
Front End Planning
Project Execution
Project Close-out

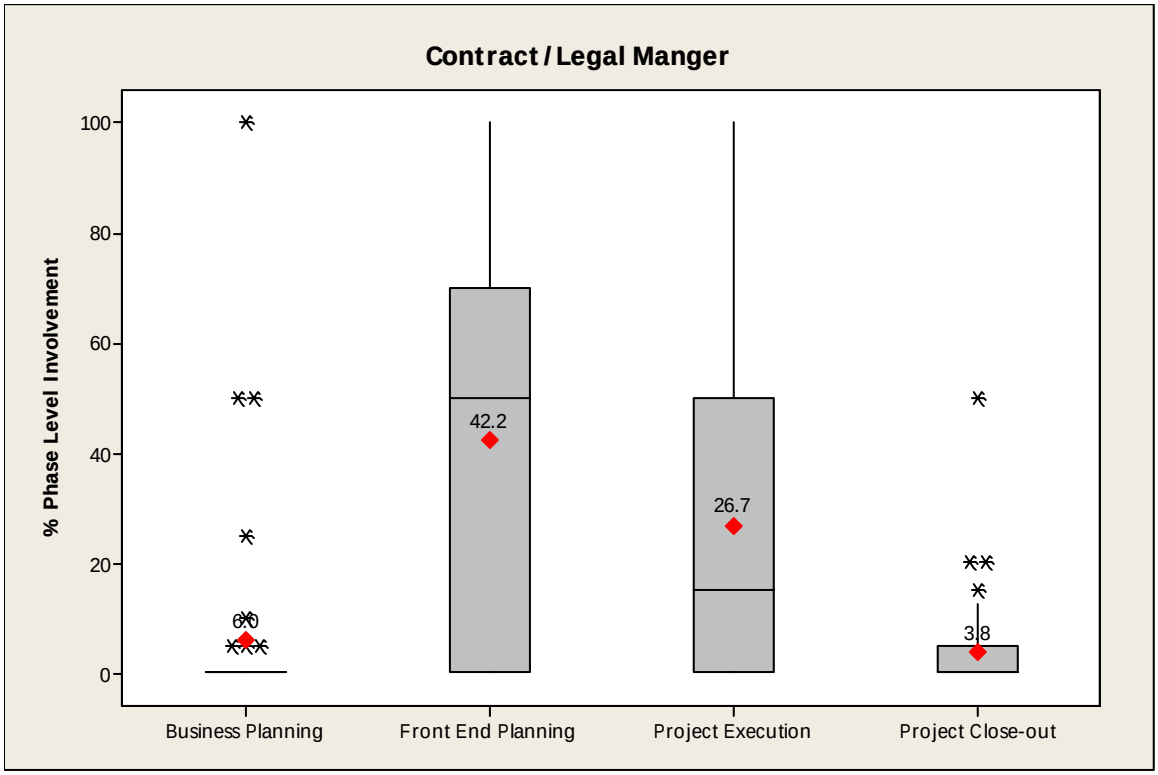

Finance Manager
% Phase Level Involvement
100
80
60
40
20
0
25.1
30.8
9.8
3.5
Business Planning
Front End Planning
Project Execution
Project Close-out

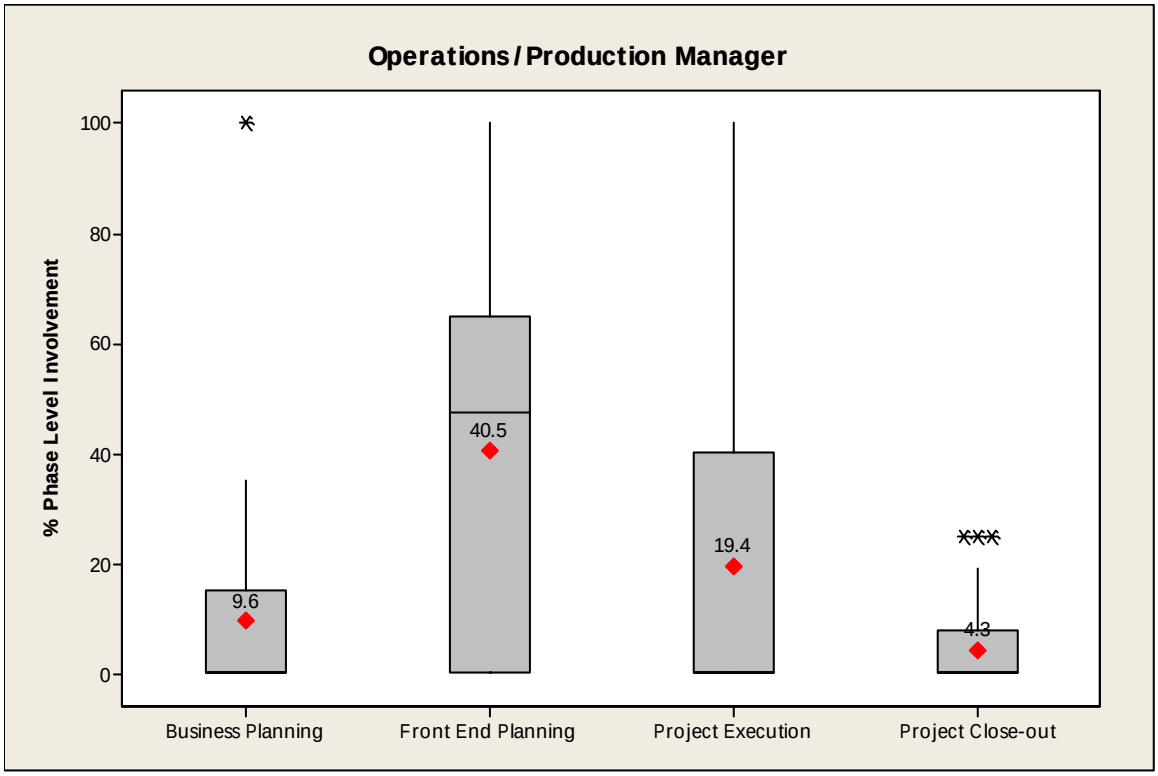

Marketing/Sales Manager
% Phase Level Involvement
100
80
60
40
20
0
12.4
1.5
0.2
0.1
Business Planning
Front End Planning
Project Execution
Project Close-out

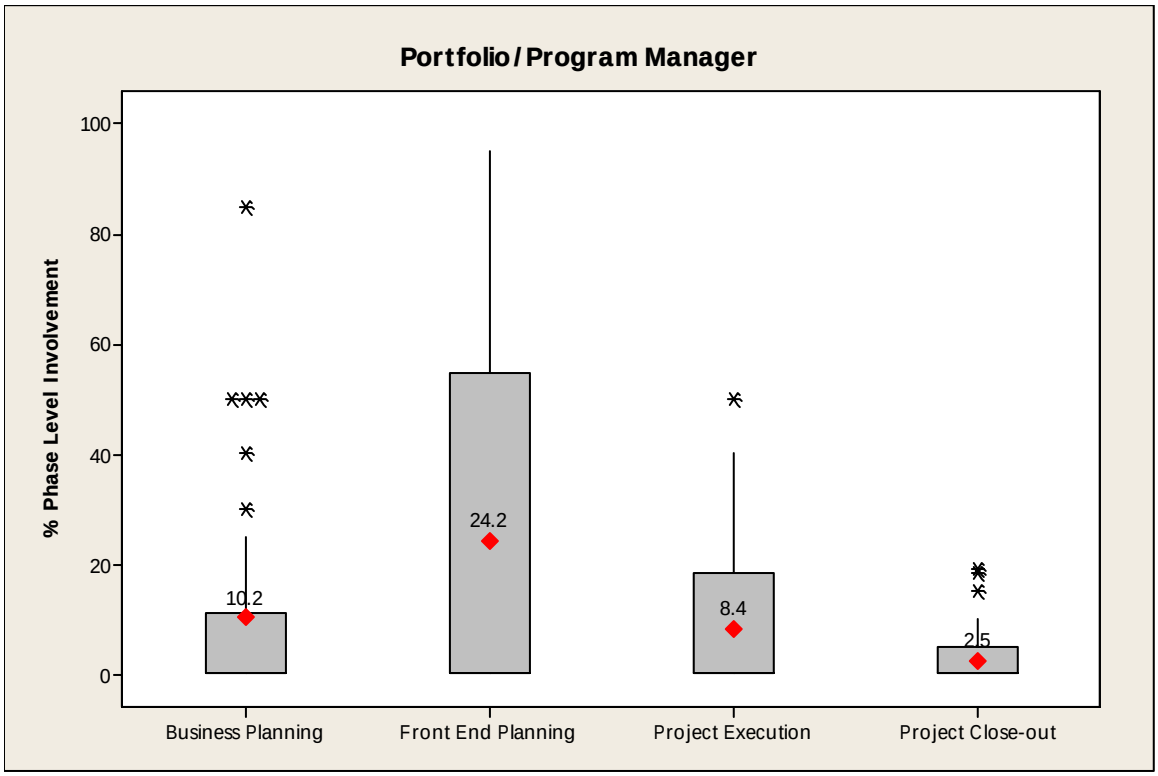

Human Resource Manager
% Phase Level Involvement
100
80
60
40
20
0
7.7
4.3
Business Planning
Front End Planning
Project Execution
Project Close-out

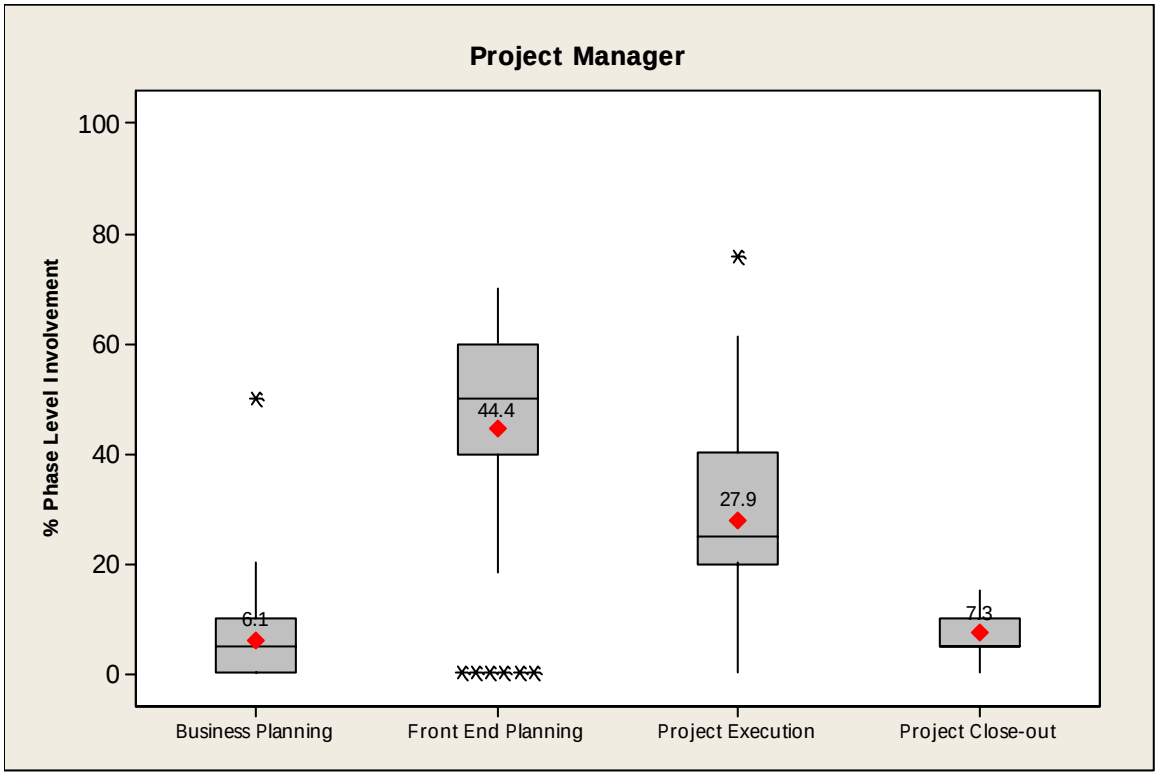

Information Technology Manager
% Phase Level Involvement
100
80
60
40
20
0
19.8
17.0
0.7
3.0
Business Planning
Front End Planning
Project Execution
Project Close-out

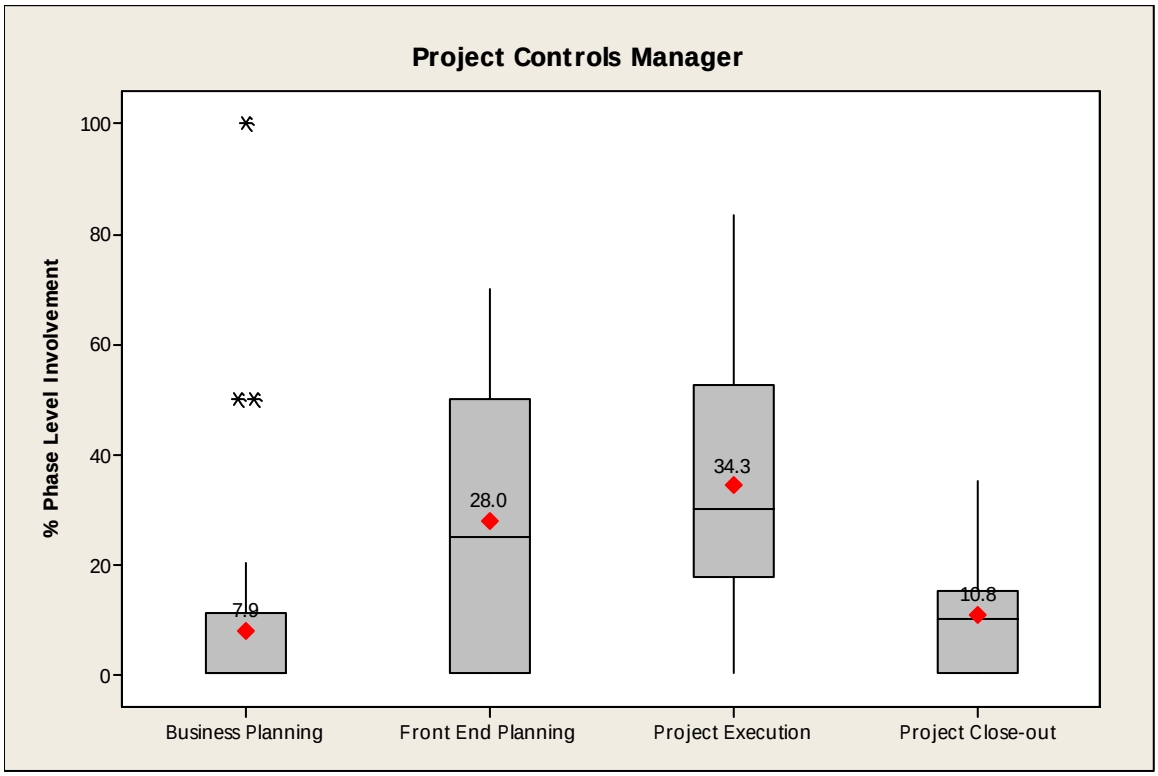

Facility / Plant Manager
% Phase Level Involvement
100
80
60
40
20
0
22.1
39.3
16.8
7.5
Business Planning
Front End Planning
Project Execution
Project Close-out

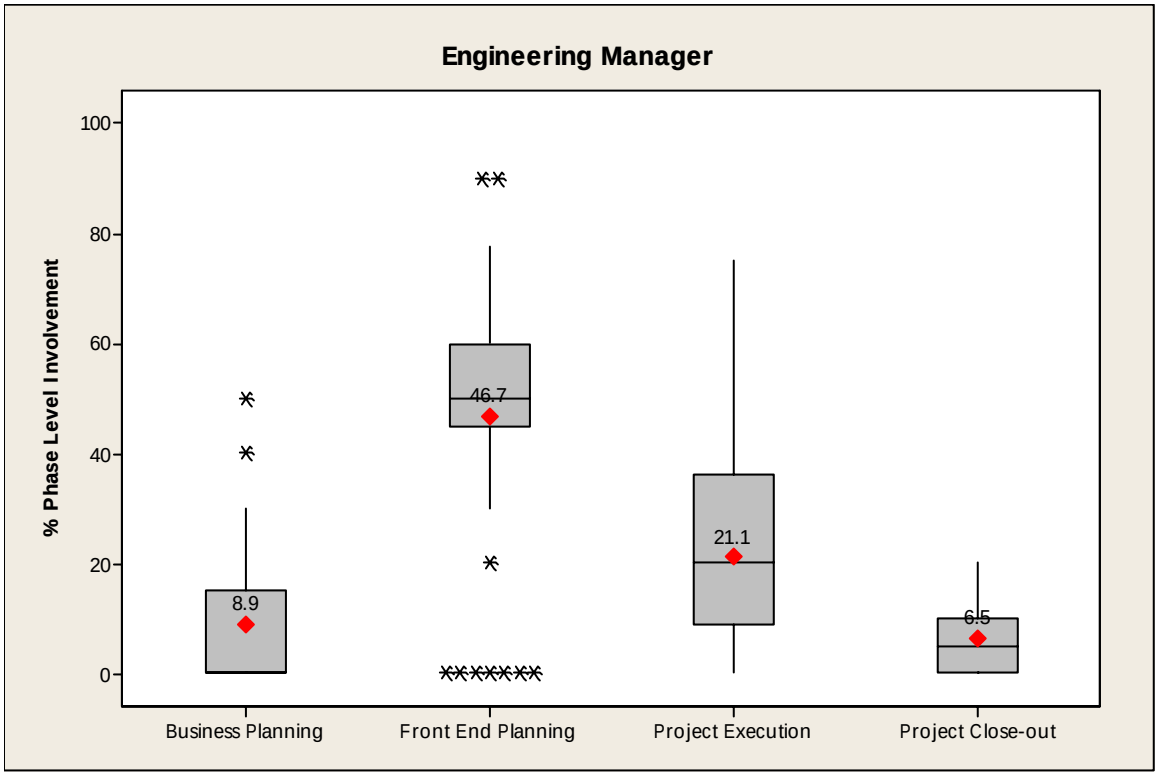

Contract / Legal Manger
% Phase Level Involvement
100
80
60
40
20
0
6.0
42.2
26.7
3.8
Business Planning
Front End Planning
Project Execution
Project Close-out

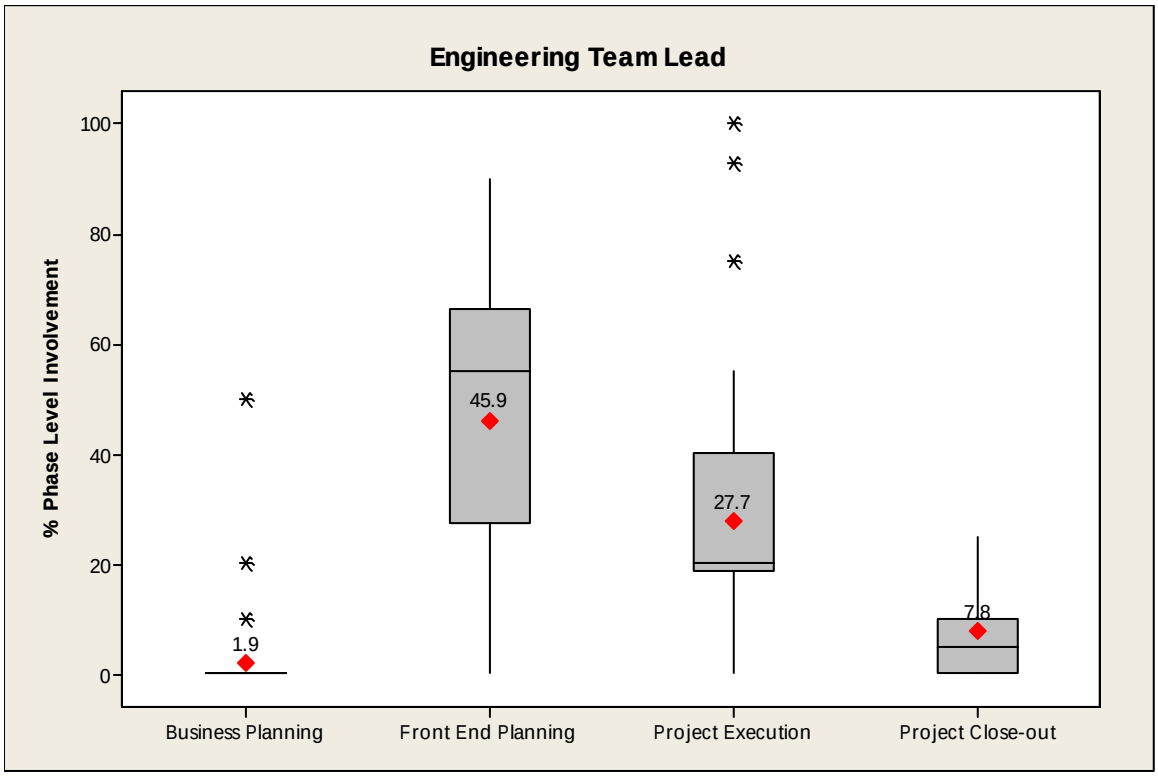

Operations / Production Manager
% Phase Level Involvement
100
80
60
40
20
0
9.6
40.5
19.4
4.3
Business Planning
Front End Planning
Project Execution
Project Close-out

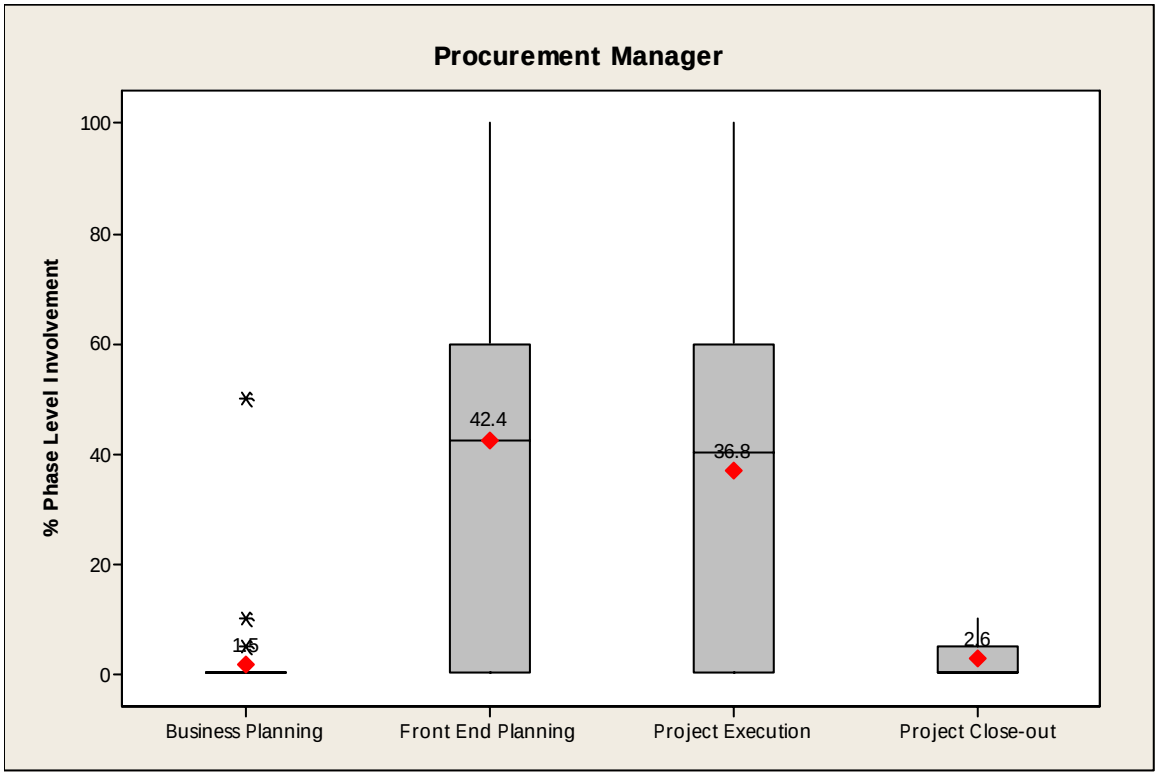

Portfolio / Program Manager
% Phase Level Involvement
100
80
60
40
20
0
10.2
24.2
8.4
2.5
Business Planning
Front End Planning
Project Execution
Project Close-out

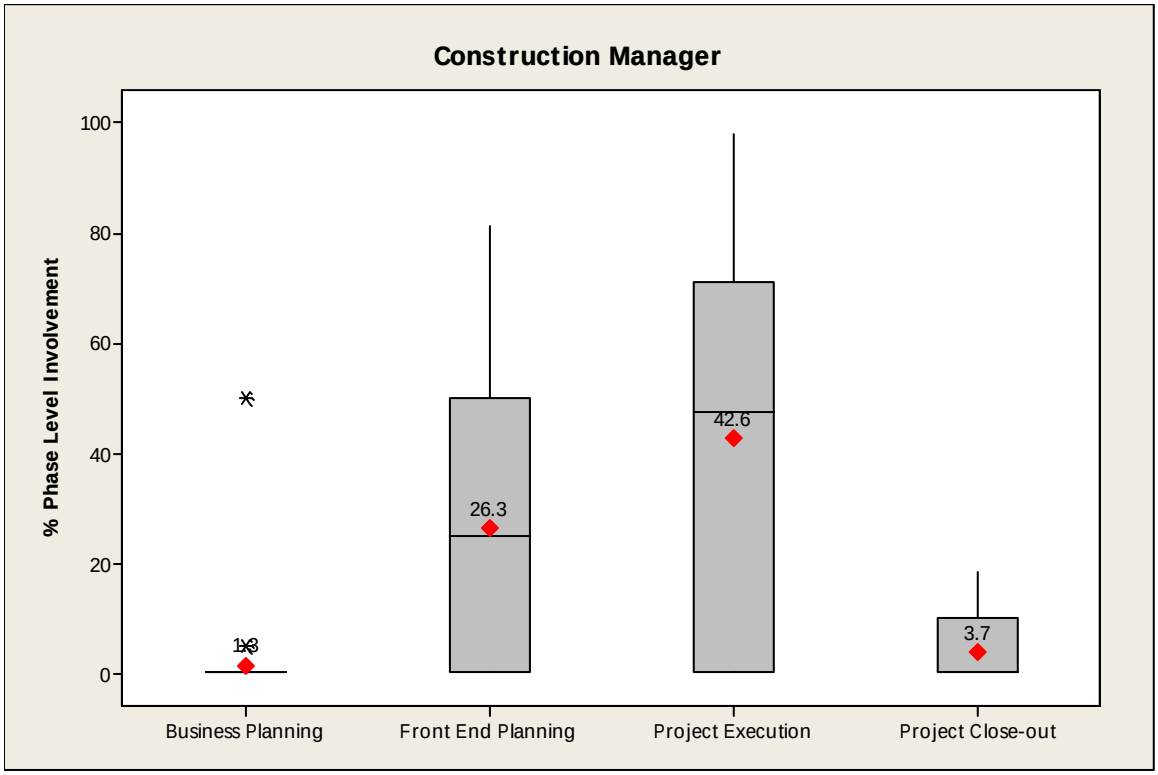

Project Manager
% Phase Level Involvement
100
80
60
40
20
0
6.1
44.4
27.9
7.3
Business Planning
Front End Planning
Project Execution
Project Close-out

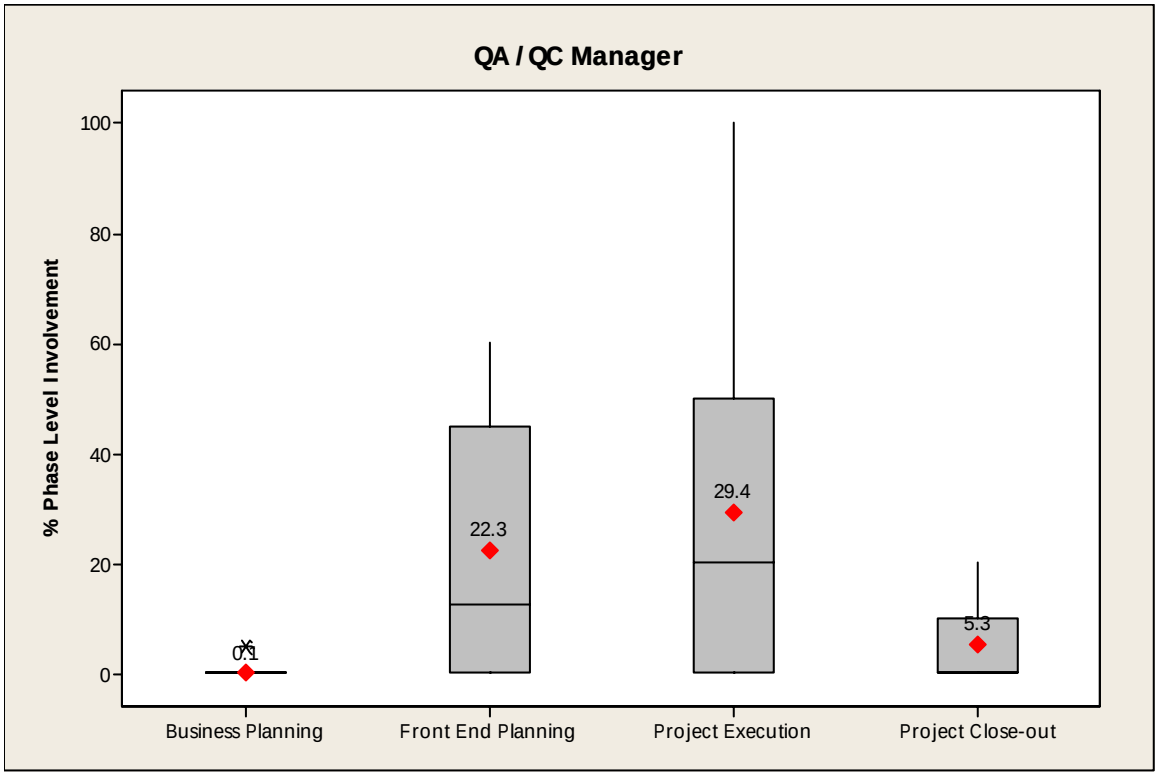

Project Controls Manager
% Phase Level Involvement
100
80
60
40
20
0
7.9
28.0
34.3
10.8
Business Planning
Front End Planning
Project Execution
Project Close-out

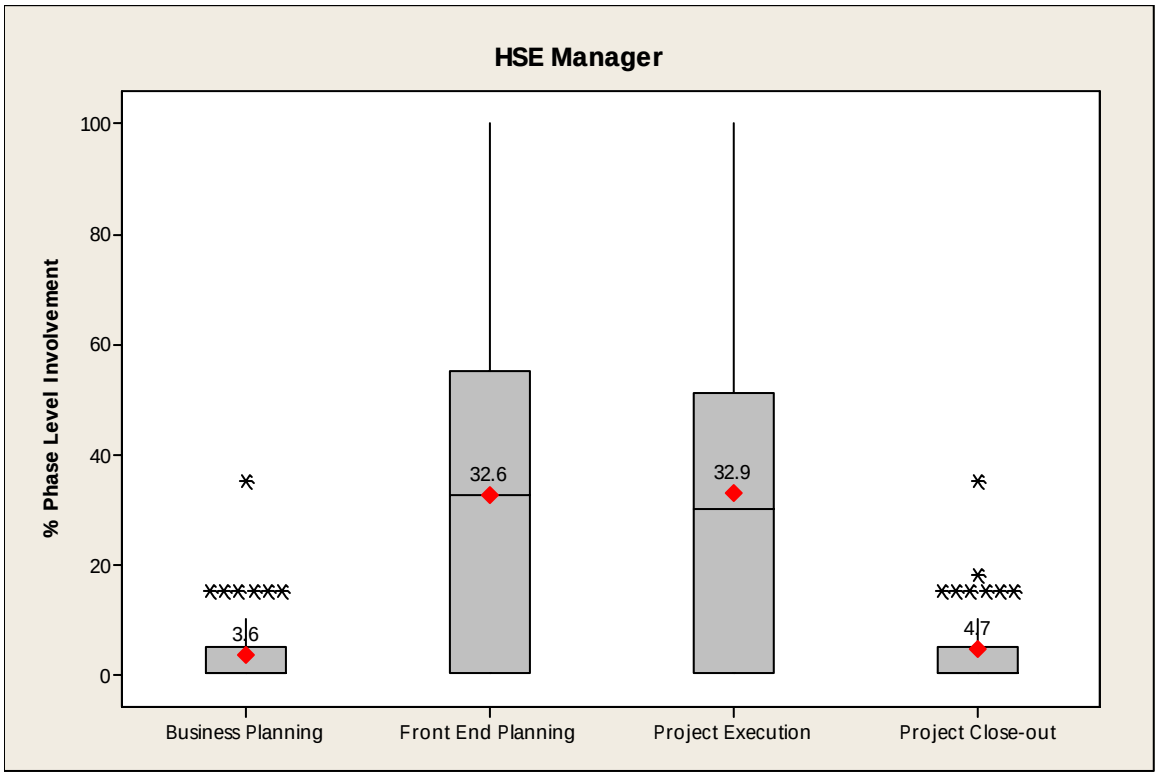

Engineering Manager
% Phase Level Involvement
100
80
60
40
20
0
46.7
21.1
8.9
6.5
Business Planning
Front End Planning
Project Execution
Project Close-out

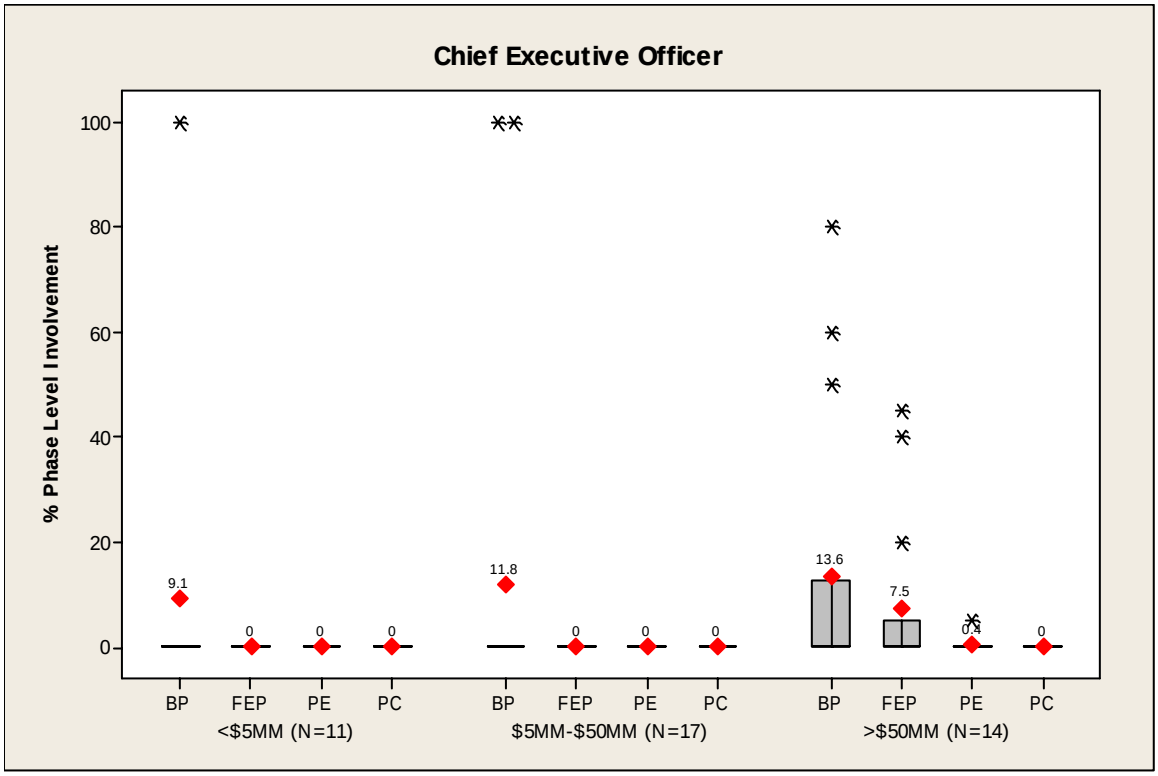

Engineering Team Lead
% Phase Level Involvement
100
80
60
40
20
0
45.9
27.7
7.8
1.9
Business Planning
Front End Planning
Project Execution
Project Close-out


Procurement Manager
% Phase Level Involvement
100
80
60
40
20
0
42.4
36.8
2.6
Business Planning
Front End Planning
Project Execution
Project Close-out


Construction Manager
% Phase Level Involvement
100
80
60
40
20
0
26.3
42.6
3.7
Business Planning
Front End Planning
Project Execution
Project Close-out


QA / QC Manager
% Phase Level Involvement
100
80
60
40
20
0
22.3
29.4
5.3
0.1
Business Planning
Front End Planning
Project Execution
Project Close-out


HSE Manager
% Phase Level Involvement
100
80
60
40
20
0
32.6
32.9
3.6
4.7
Business Planning
Front End Planning
Project Execution
Project Close-out


Chief Executive Officer
% Phase Level Involvement
100
80
60
40
20
0
9.1
0
0
0
11.8
0
0
0
13.6
7.5
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BP
FEP
PE
PC
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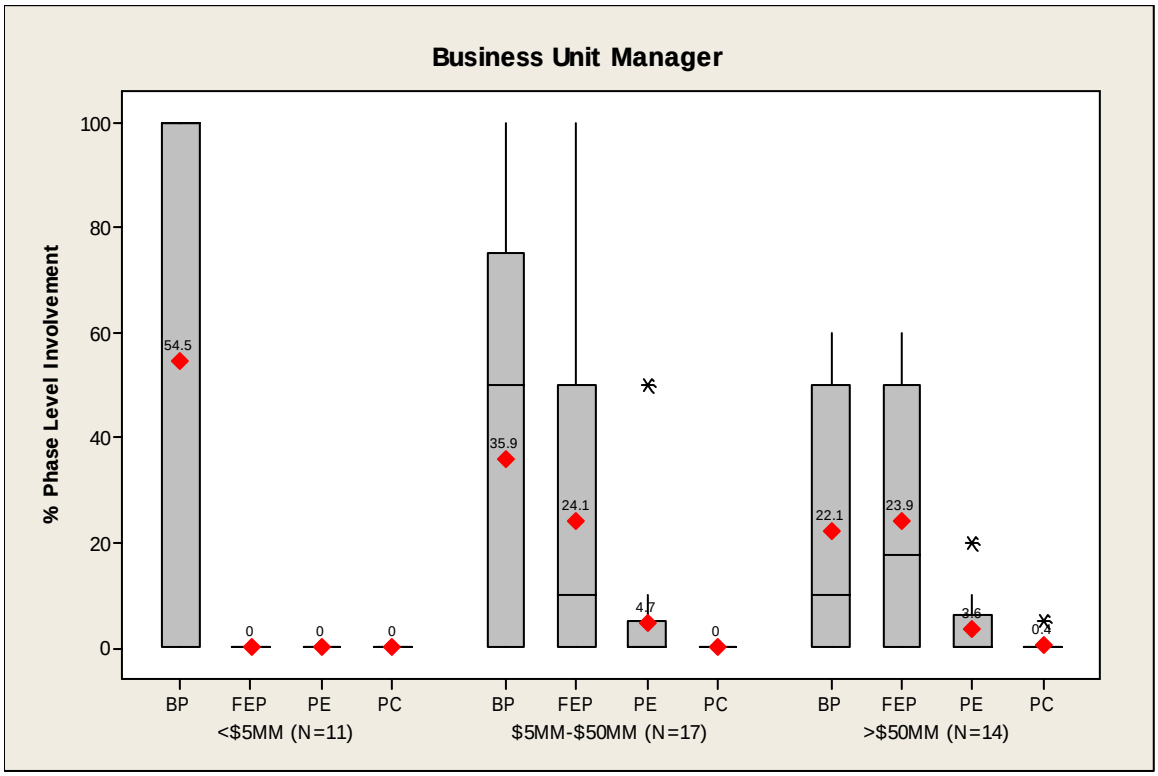
$5MM-$50MM (N=17)
>$50MM (N=14)


Business Unit Manager
% Phase Level Involvement
100
80
60
40
20
0
54.5
0
0
0
35.9
24.1
4.7
0
22.1
23.9
3.6
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BP
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PE
PC
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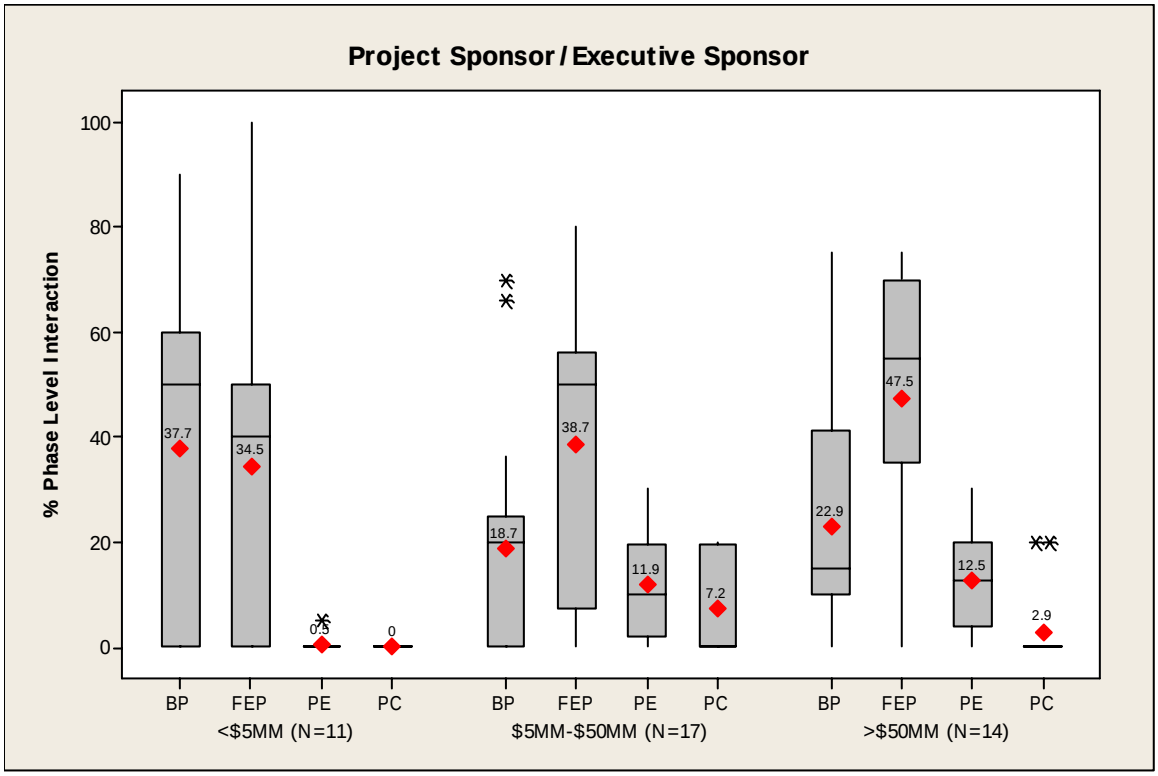
$5MM-$50MM (N=17)
>$50MM (N=14)


Project Sponsor / Executive Sponsor
% Phase Level Interaction
100
80
60
40
20
0
37.7
34.5
0.9
0
18.7
38.7
11.9
7.2
22.9
47.5
12.5
2.9
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FEP
PE
PC
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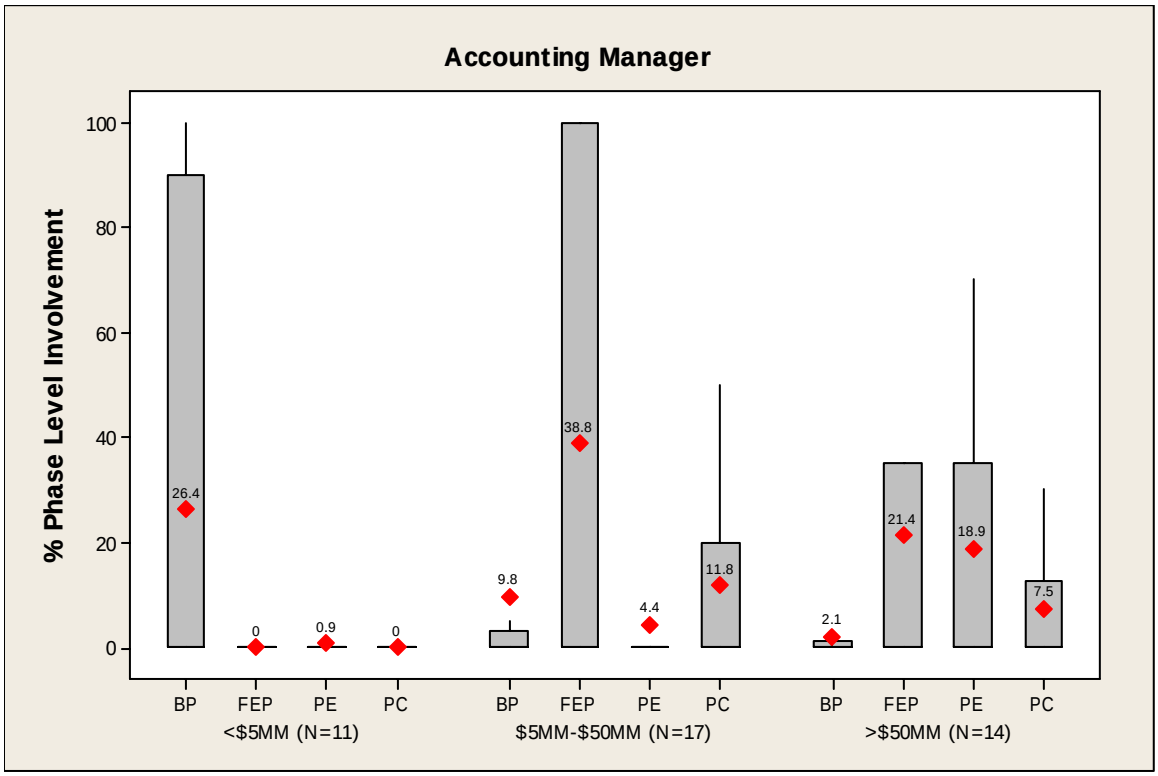
Accounting Manager
% Phase Level Involvement
100
80
60
40
20
0
26.4
0
0.9
0
9.8
38.8
4.4
11.8
2.1
21.4
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FEP
PE
PC
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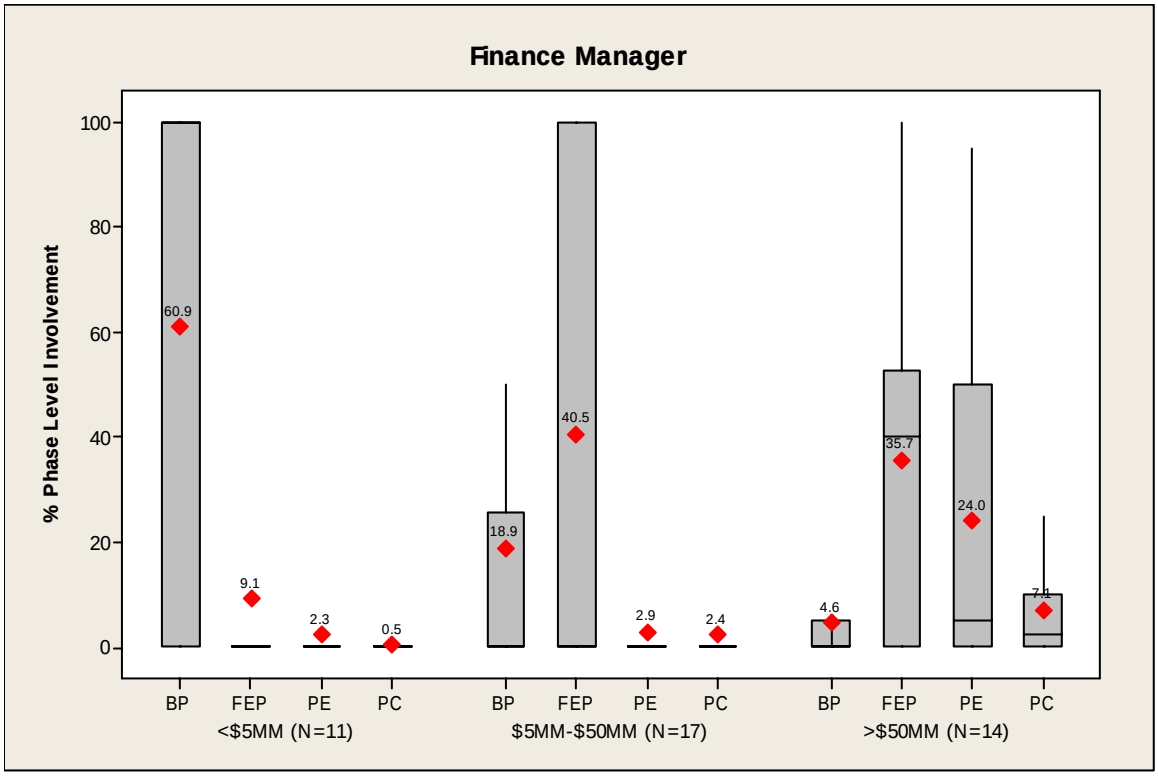
Finance Manager
% Phase Level Involvement
100
80
60
40
20
0
60.9
9.1
2.3
0.5
18.9
40.5
2.9
2.4
4.6
35.7
24.0
7.1
BP
FEP
PE
PC
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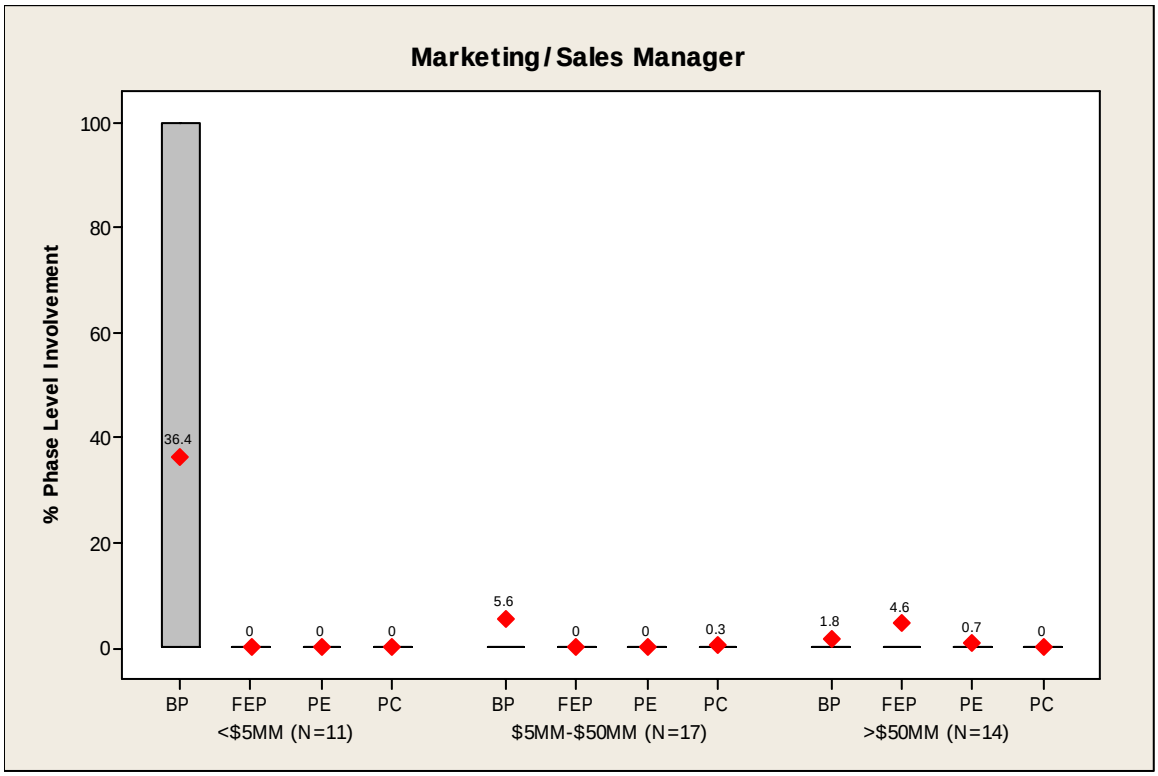
>$50MM (N=14)


Marketing/Sales Manager
% Phase Level Involvement
100
80
60
40
20
0
36.4
0
0
0
5.6
0
0
0.3
1.8
4.6
0.7
0
BP
FEP
PE
PC
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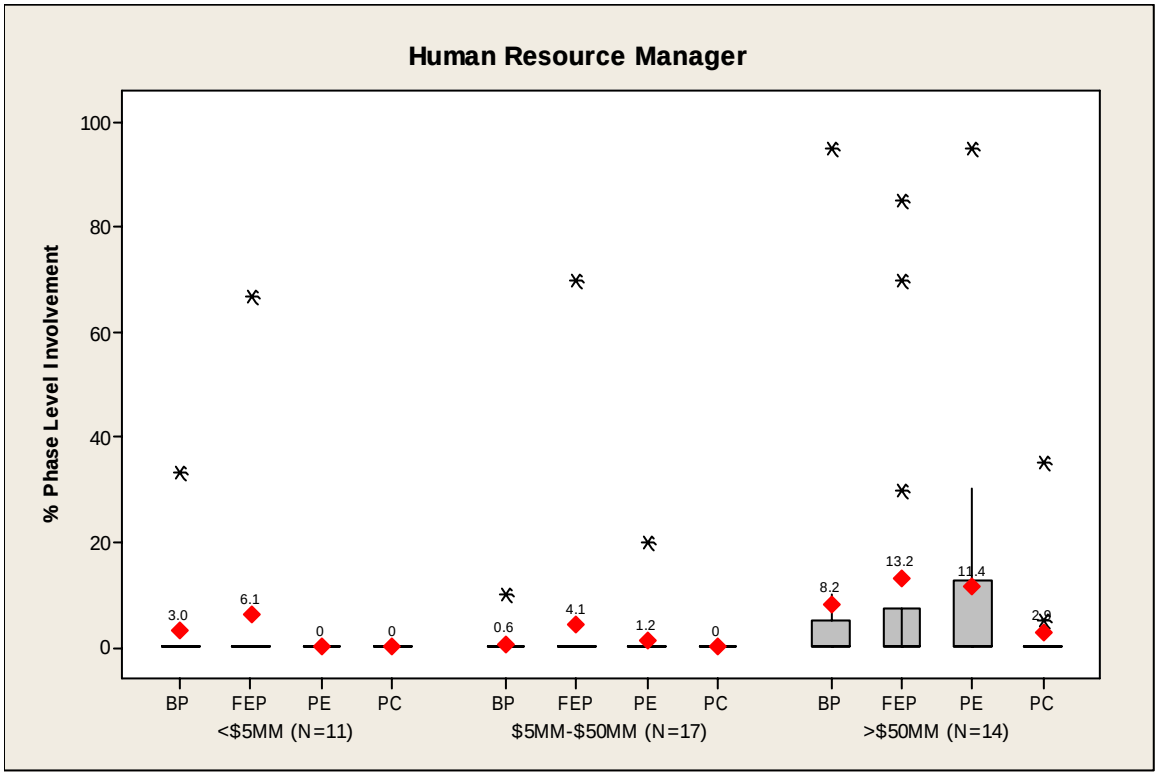
>$50MM (N=14)


Human Resource Manager
% Phase Level Involvement
100
80
60
40
20
0
3.0
6.1
0
0
0.6
4.1
1.2
0
8.2
13.2
11.4
2.8
BP
FEP
PE
PC
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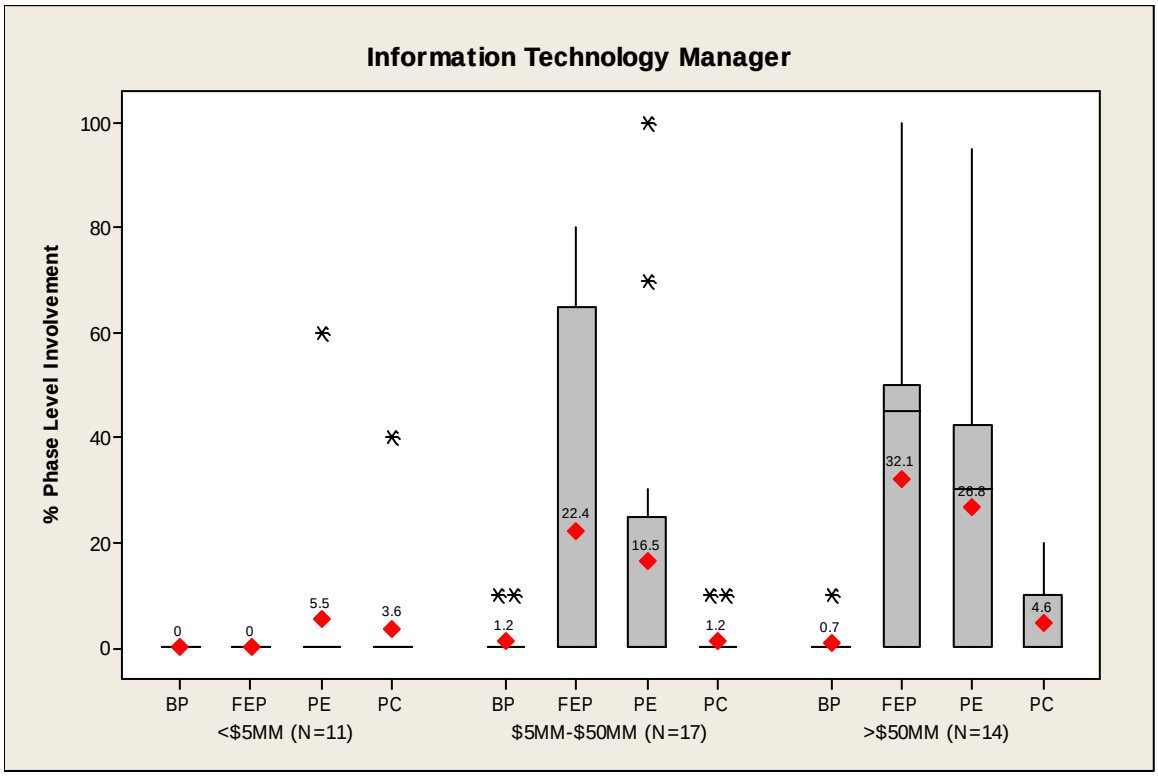
$5MM-$50MM (N=17)
>$50MM (N=14)


Information Technology Manager
% Phase Level Involvement
100
80
60
40
20
0
0
0
5.5
3.6
1.2
22.4
16.5
1.2
0.7
32.1
26.8
4.6
BP
FEP
PE
PC
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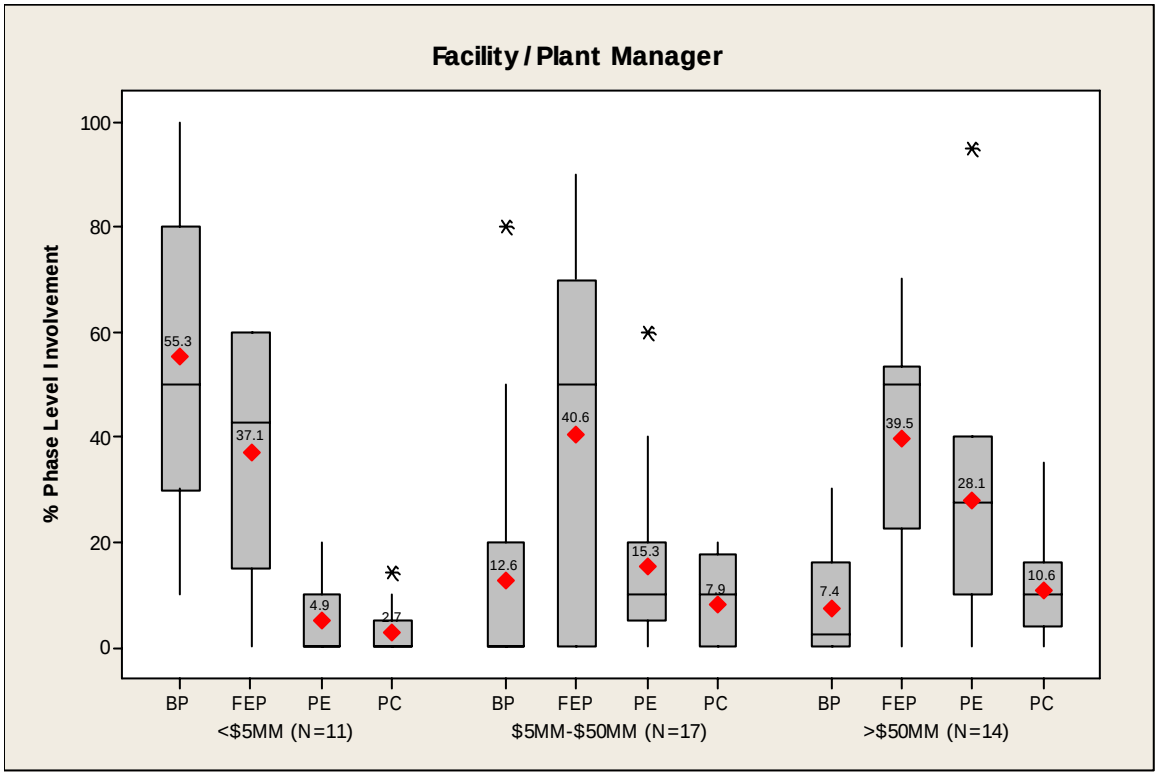
>$50MM (N=14)


Facility / Plant Manager
% Phase Level Involvement
100
80
60
40
20
0
55.3
37.1
4.9
2.7
12.6
40.6
15.3
7.9
7.4
39.5
28.1
10.6
BP
FEP
PE
PC
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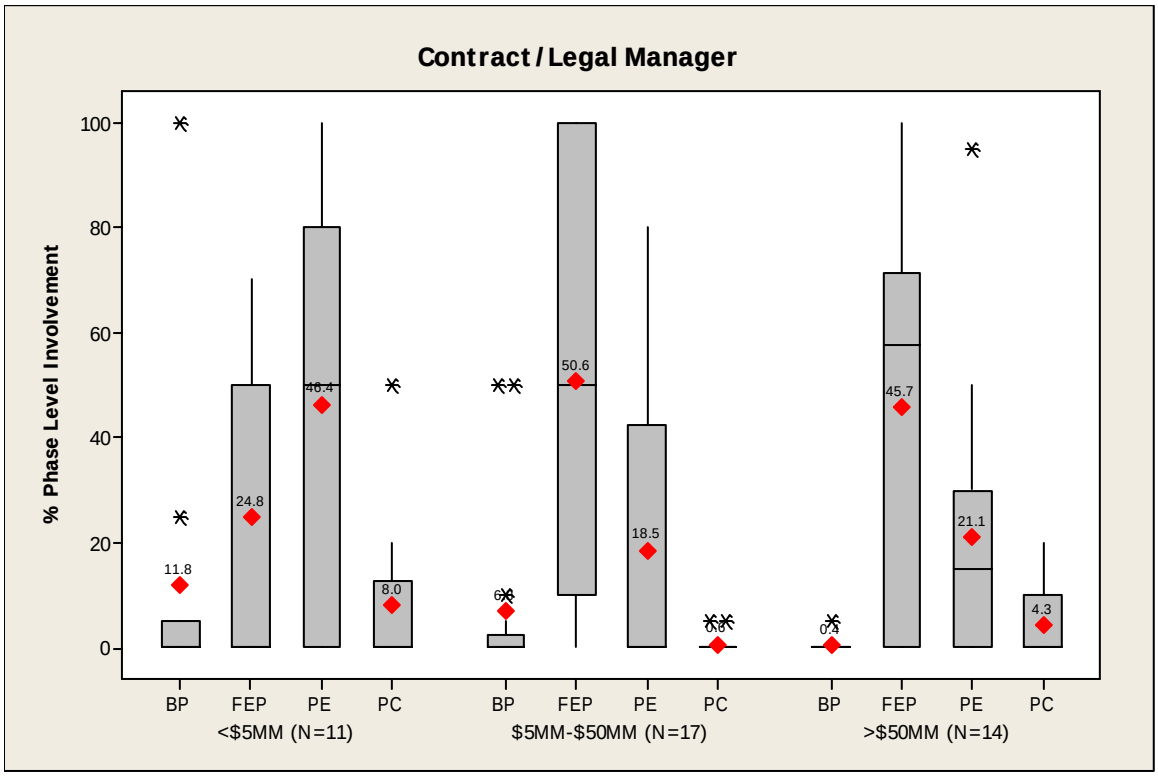
>$50MM (N=14)


Contract / Legal Manager
% Phase Level Involvement
100
80
60
40
20
0
11.8
24.8
46.4
8.0
50.6
18.5
45.7
21.1
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FEP
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PC
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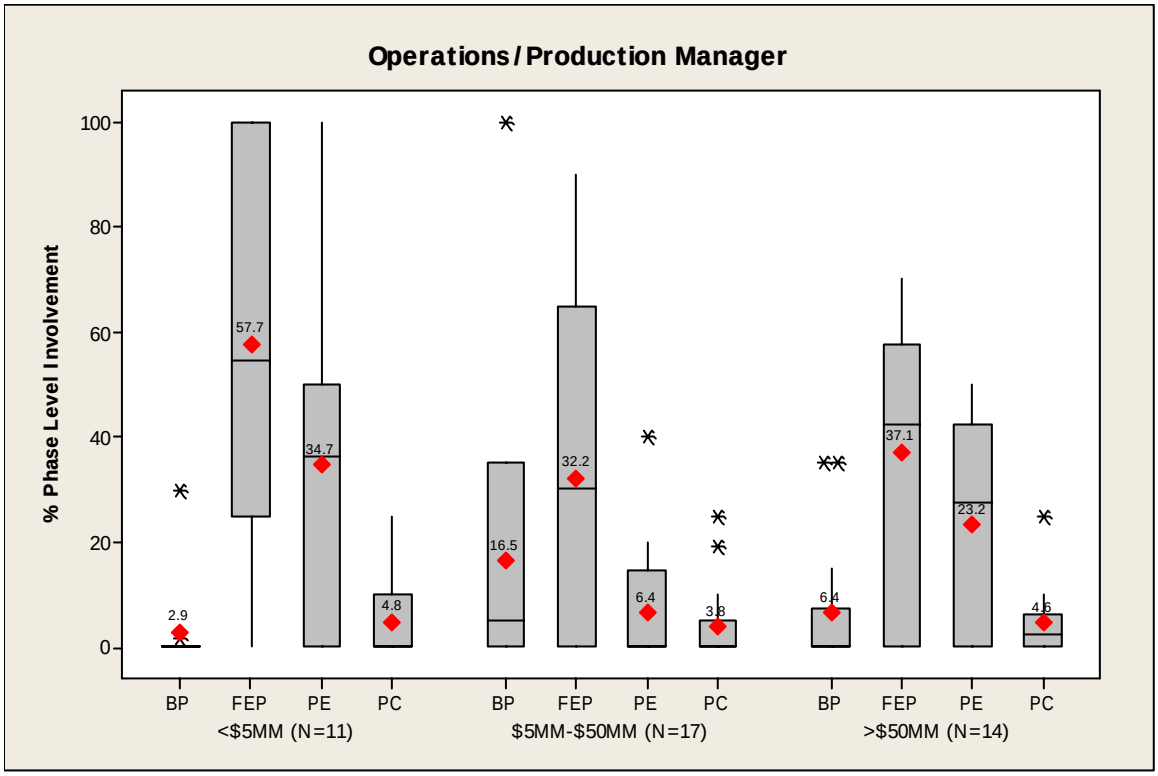
Operations / Production Manager
% Phase Level Involvement
100
80
60
40
20
0
57.7
34.7
4.8
2.9
16.5
32.2
6.4
3.8
6.4
37.1
23.2
4.6
BP
FEP
PE
PC
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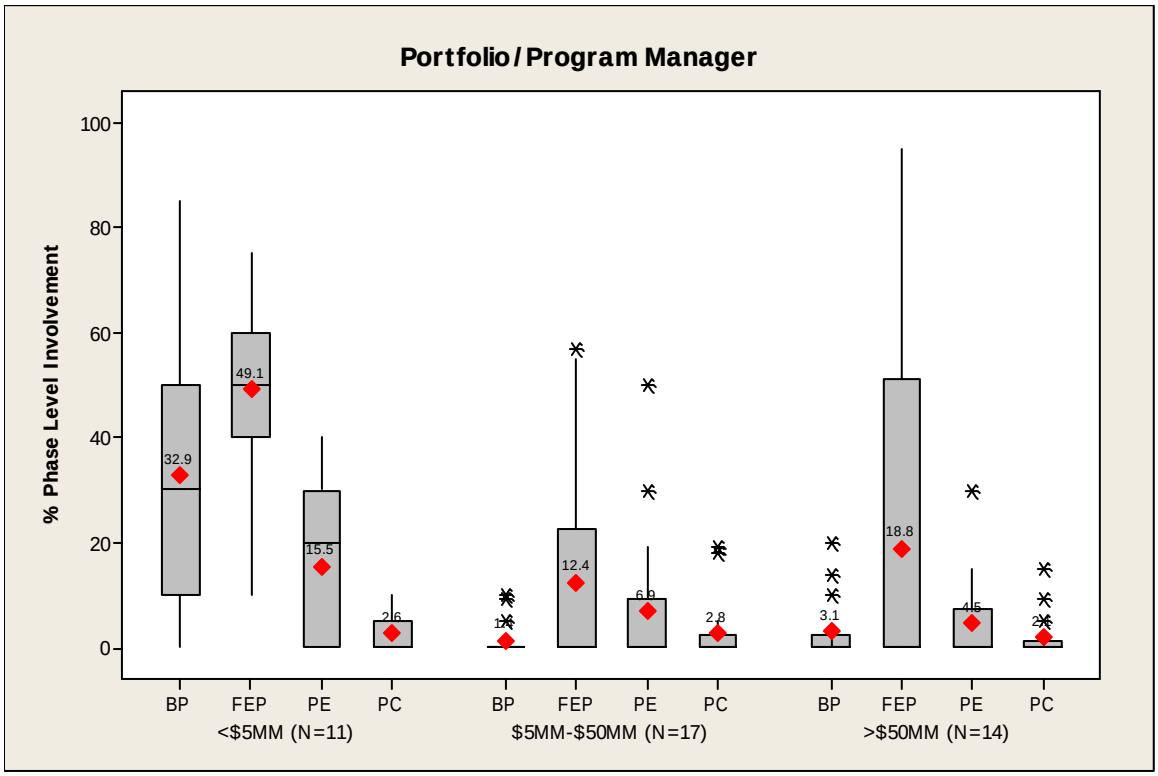
Portfolio / Program Manager
% Phase Level Involvement
100
80
60
40
20
0
32.9
49.1
15.5
2.6
12.4
6.9
2.8
3.1
18.8
4.5
BP
FEP
PE
PC
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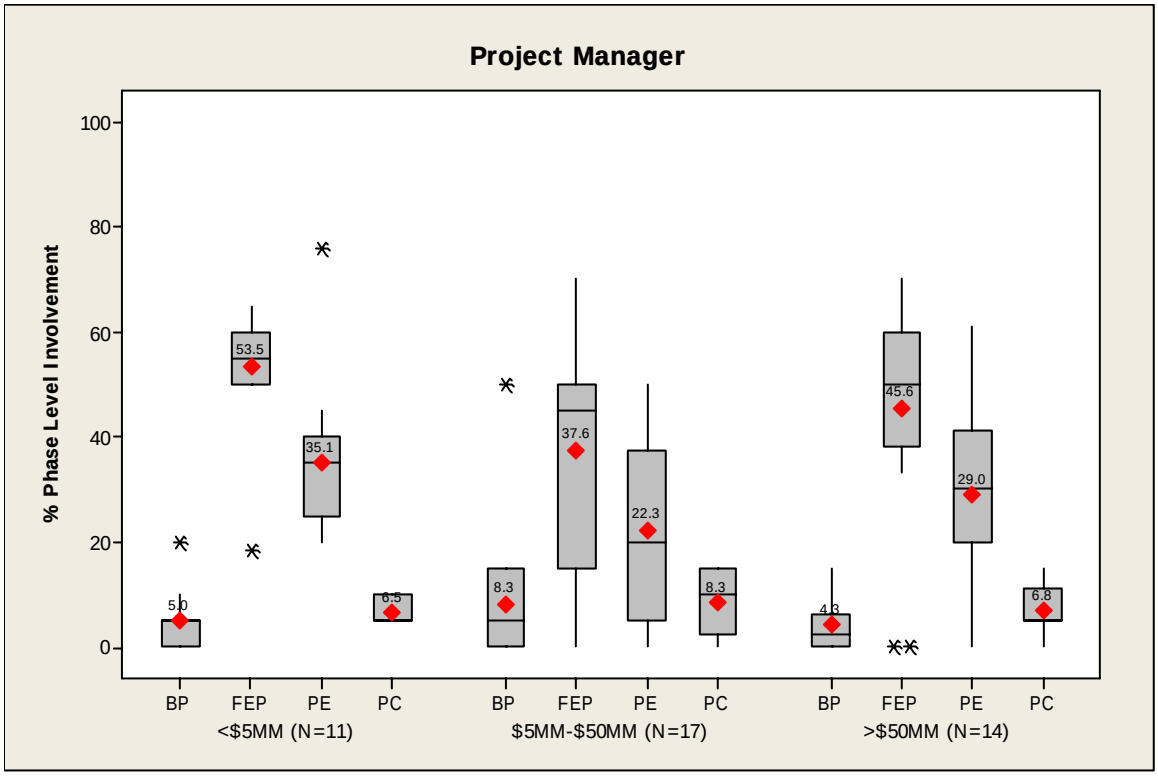
$5MM-$50MM (N=17)
>$50MM (N=14)


Project Manager
% Phase Level Involvement
100
80
60
40
20
0
53.5
35.1
6.5
8.3
37.6
22.3
8.3
4.8
45.6
29.0
6.8
BP
FEP
PE
PC
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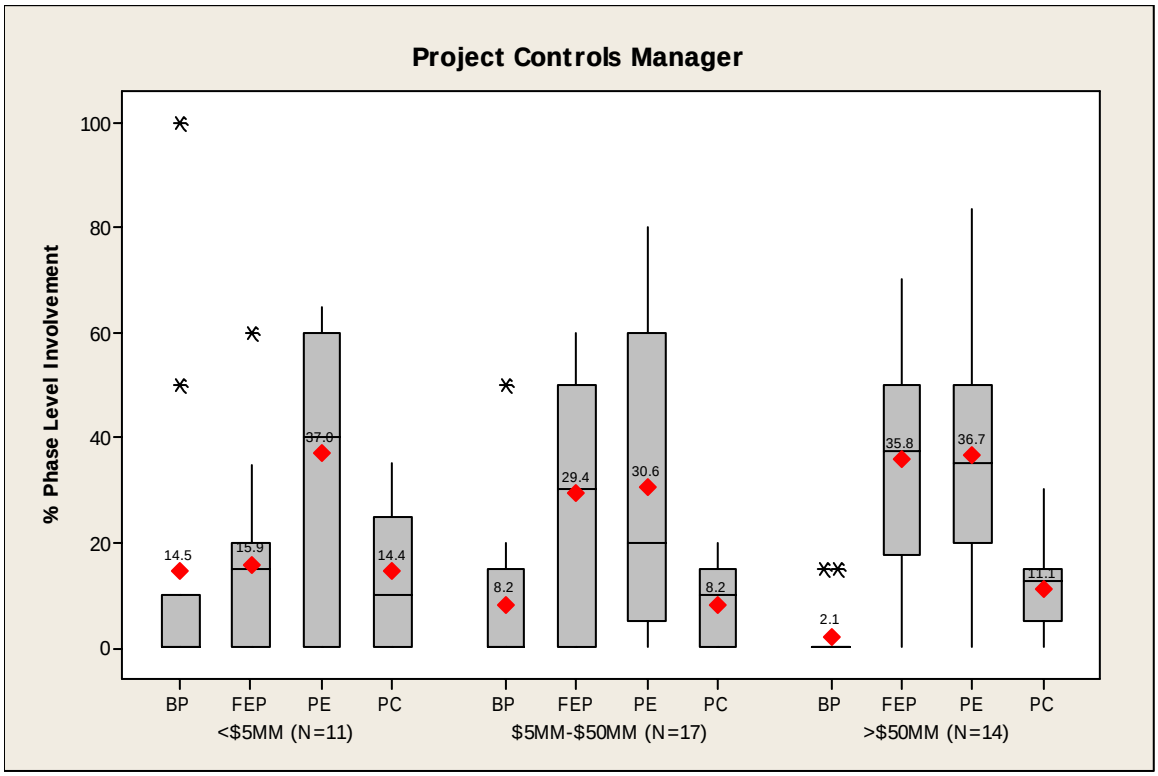
Project Controls Manager
% Phase Level Involvement
100
80
60
40
20
0
14.5
15.9
37.8
14.4
8.2
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30.6
8.2
2.1
35.8
36.7
11.1
BP
FEP
PE
PC
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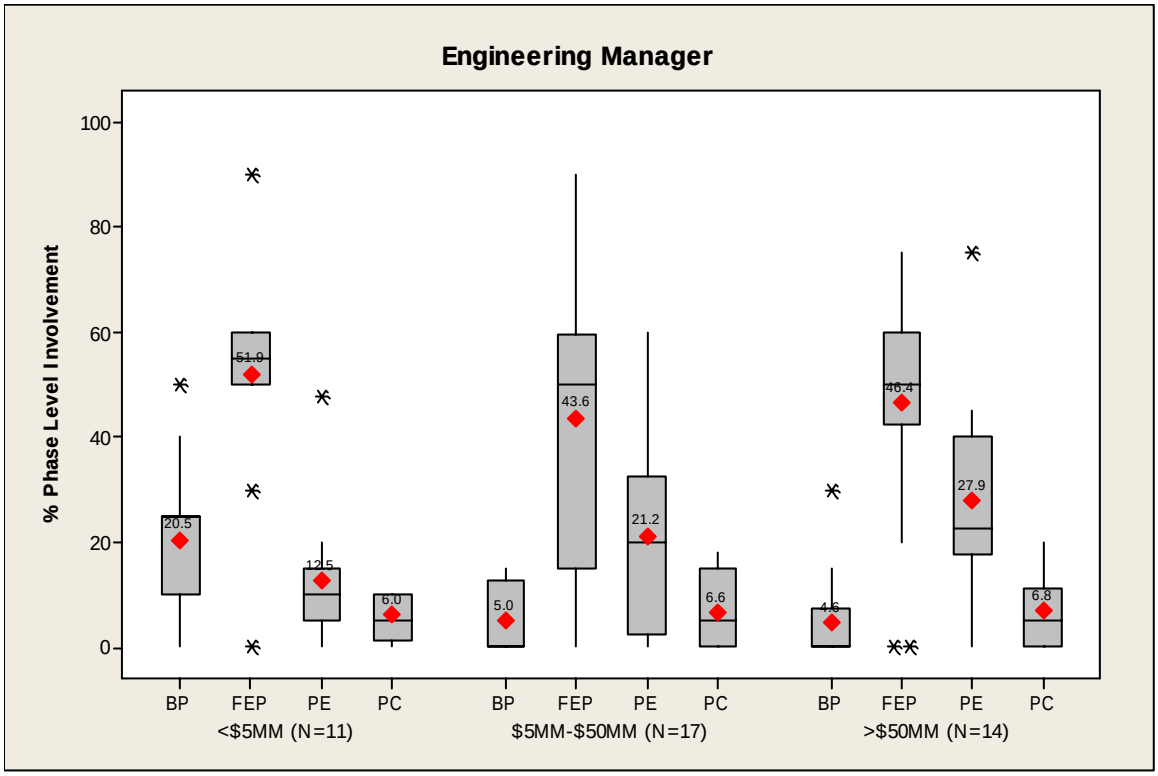
Engineering Manager
% Phase Level Involvement
100
80
60
40
20
0
20.5
51.9
12.5
6.0
5.0
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21.2
6.6
4.6
46.4
27.9
6.8
BP
FEP
PE
PC
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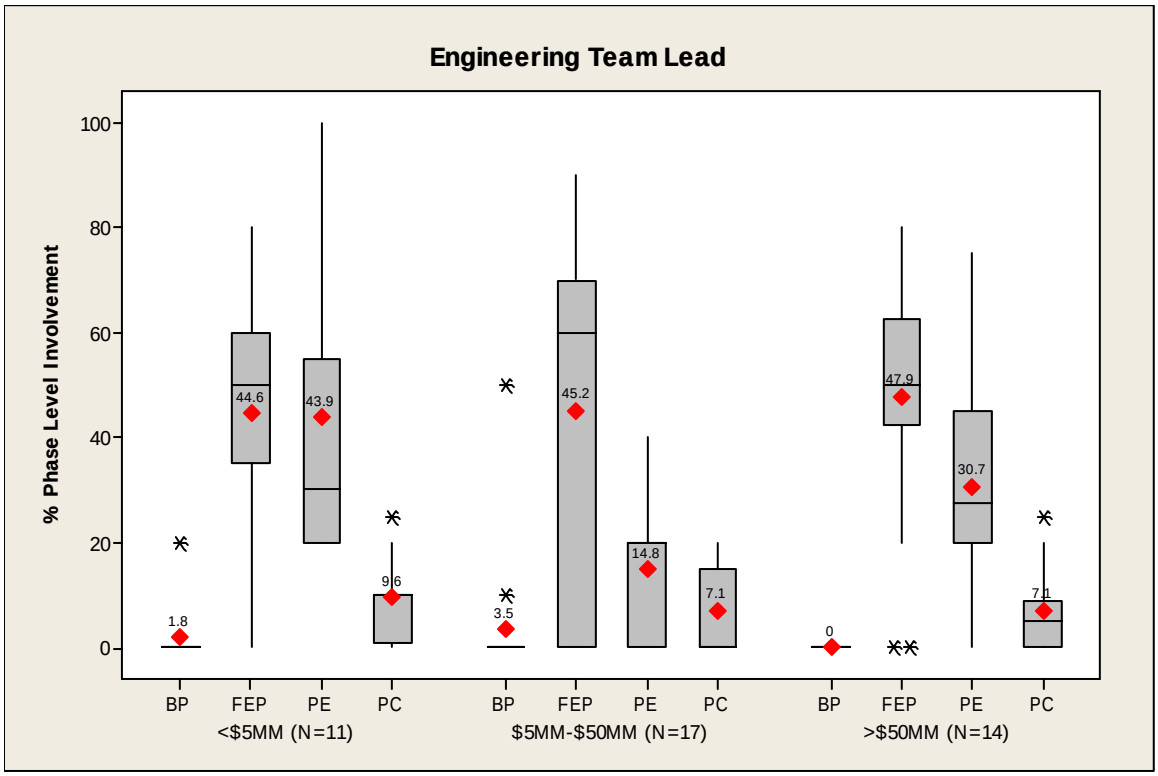
Engineering Team Lead
% Phase Level Involvement
100
80
60
40
20
0
1.8
44.6
43.9
9.6
3.5
45.2
14.8
7.1
0
47.9
30.7
7.1
BP
FEP
PE
PC
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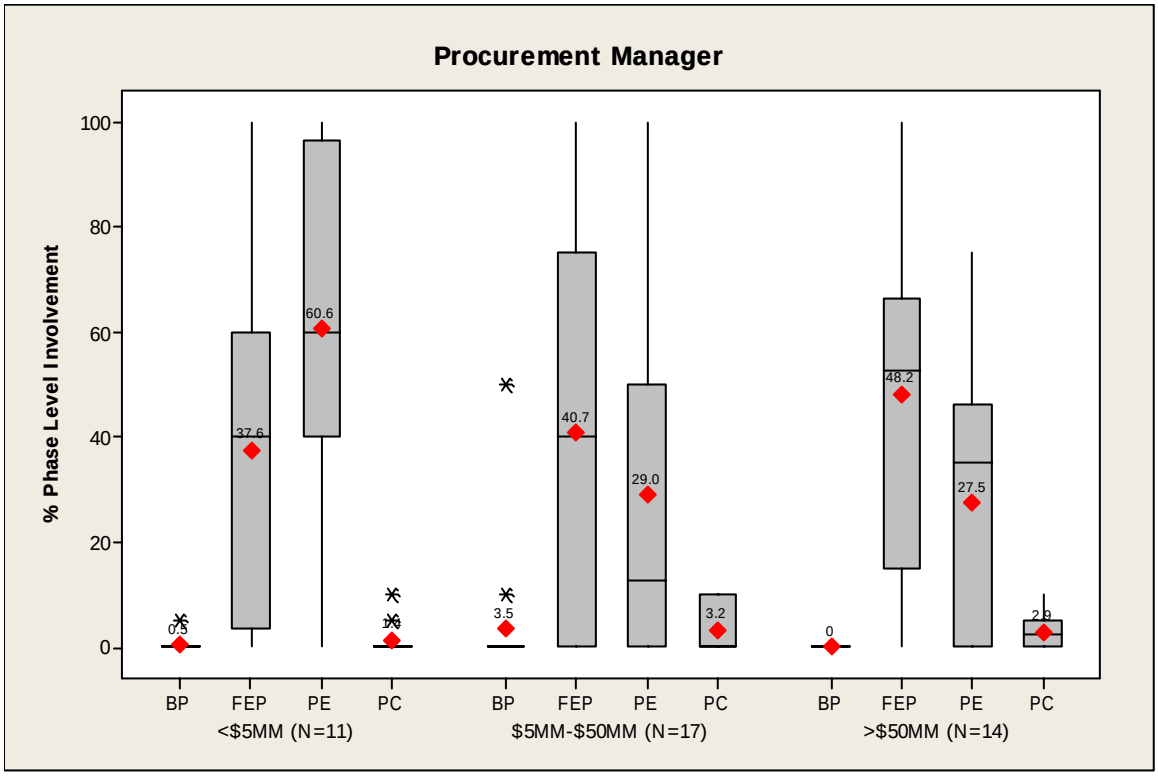
Procurement Manager
% Phase Level Involvement
100
80
60
40
20
0
60.6
37.6
40.7
29.0
48.2
27.5
3.5
3.2
0
BP
FEP
PE
PC
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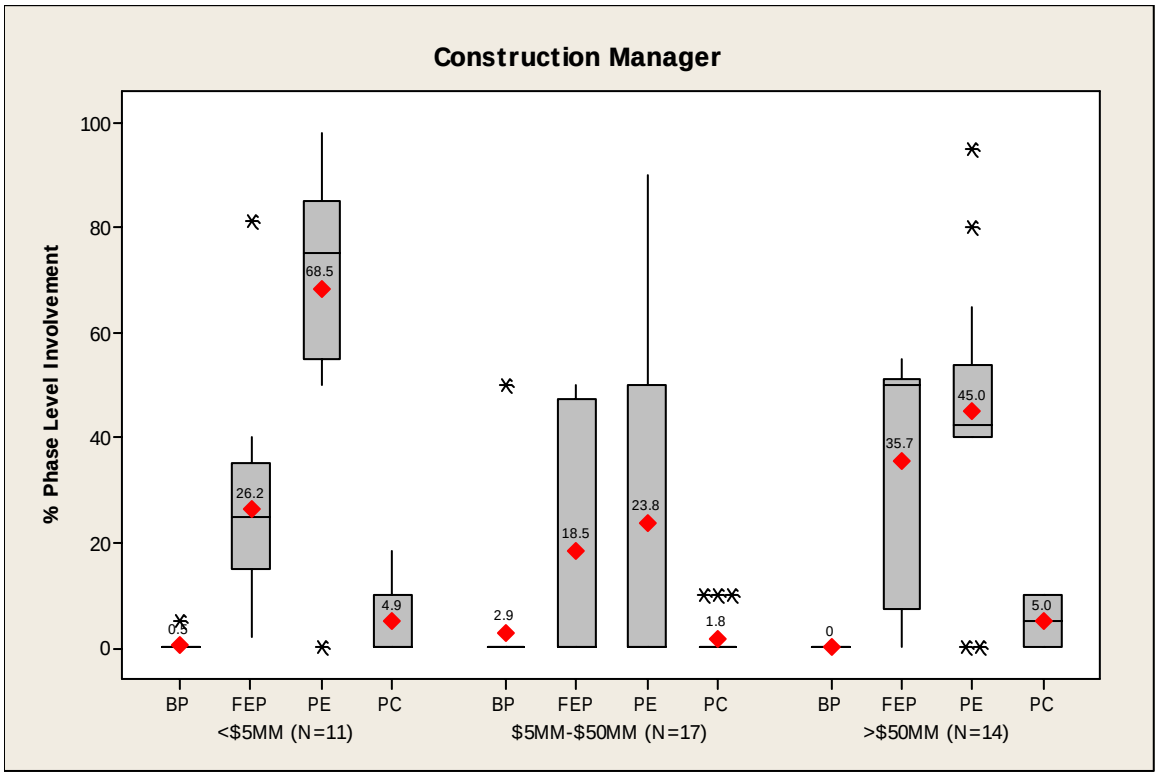
Construction Manager
% Phase Level Involvement
100
80
60
40
20
0
68.5
26.2
4.9
2.9
18.5
23.8
1.8
35.7
45.0
5.0
0
BP
FEP
PE
PC
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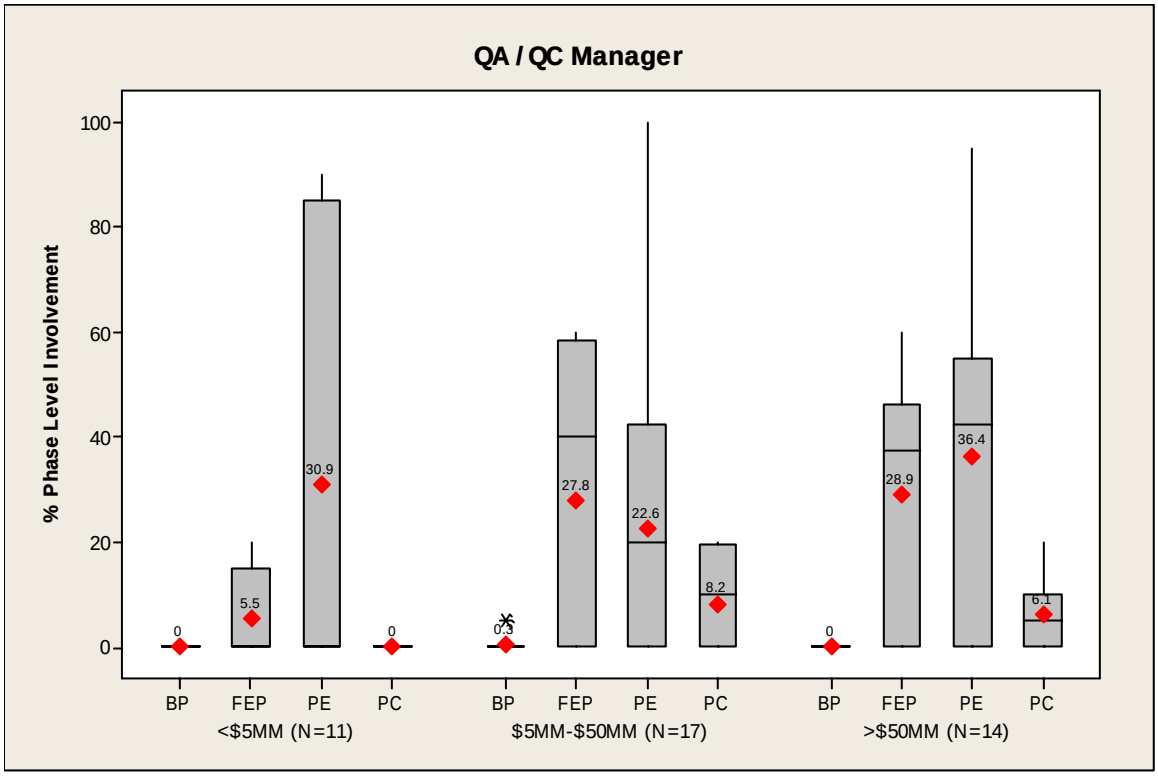
QA / QC Manager
% Phase Level Involvement
100
80
60
40
20
0
0
5.5
30.9
0
0.3
27.8
22.6
8.2
0
28.9
36.4
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FEP
PE
PC
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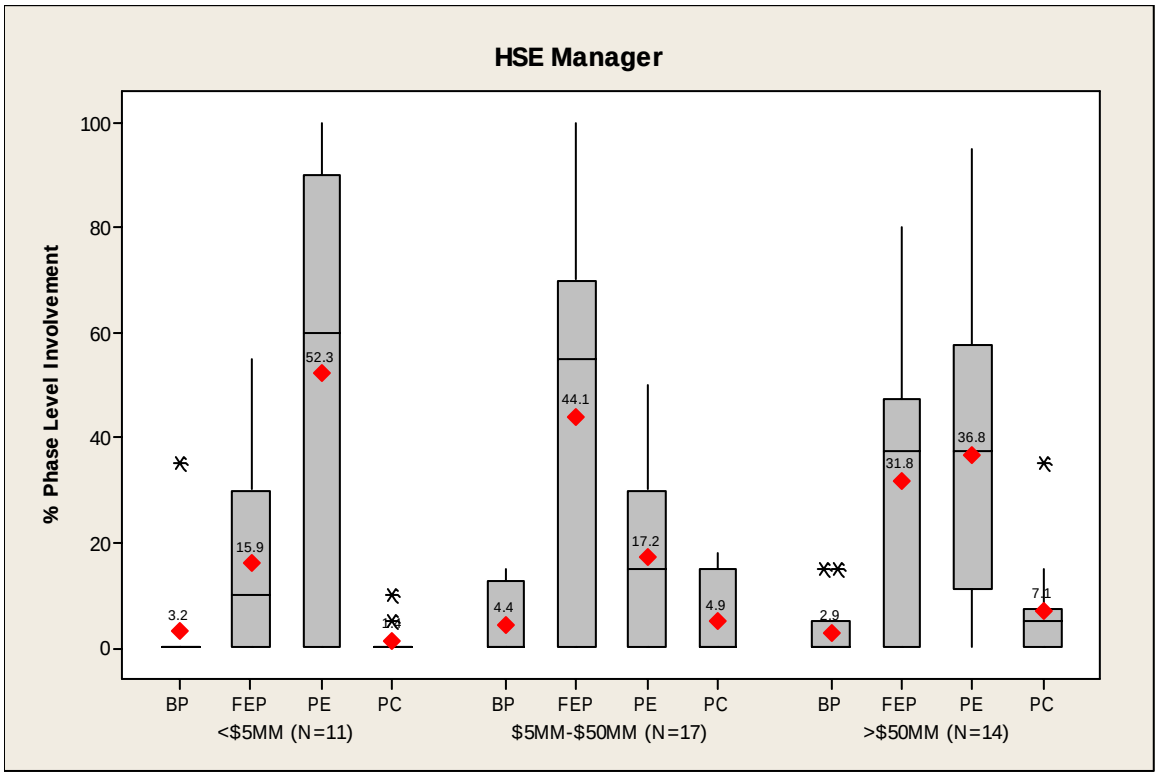
HSE Manager
% Phase Level Involvement
100
80
60
40
20
0
3.2
15.9
52.3
4.4
44.1
17.2
4.9
2.9
31.8
36.8
7.1
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FEP
PE
PC
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BIBLIOGRAPHY

Agresti, A. (2013). Categorical Data Analysis (3rd Ed). John Wiley & Sons.Mehta and Petal

Al-Hammad, A.-M. (1995). Interface Problems between Owners and Maintenance Contractors in Saudi Arabia. Journal of Performance of Constructed Facilities, 9(3), 194-205.

Al-Hammad, A.-M. (2000). "Common Interface Problems among Various Construction Parties." Journal of Performance of Constructed Facilities, 14(2), 71-74.

Al-Hammad, A.-M., and Al-Hammad, I. (1996). "Interface Problems between Building Owners and Designers." Journal of Performance of Constructed Facilities, 10(3), 123-126.

Al-Hammad, A. (1990). "A study of the interface problems between owners and contractors over the construction of residential houses in Saudi Arabia." Housing Science, 14(4), 245-257.

Al-Hammad, A. (1993). "Factors affecting the relationship between contractors and their sub-contractors in Saudi Arabia." Building Research and Information, 21(5), 269-273.

Al-Hammad, A., and Assaf, S. (1992). "Design—Construction interface problems in Saudi Arabia." Building Research and Information, 20(1), 60-63.

Alarcon, L. F., and Mardones, D. A. (1998). "Improving the design-construction interface." Proceeding of 6th Annual Conference on International Group Lean Construction ('98 IGLC), Guaruja, Brazil.

Bryde, D. (2008). "Perceptions of the impact of project sponsorship practices on project success." International Journal of Project Management, 26(8), 800-809.

Chan, W. T., Chen, C., Messner, J. I., and Chua, D. K. H. (2005). "Interface Management for China's Build--Operate--Transfer Projects." Journal of Construction Engineering and Management, 131(6), 645-655.

Chen, Q., Reichard, G., and Beliveau, Y. (2008). "Multiperspective Approach to Exploring Comprehensive Cause Factors for Interface Issues." Journal of Construction Engineering and Management, 134(6), 432-441.

Chiocchio, F., Beaulieu, G., Boudrias, J.-S., Rousseau, V., Aubé, C., and Morin, E. M. (2010). "The Project Involvement Index, psychological distress, and psychological well-being: Comparing workers from projectized and non-projectized organizations." International Journal of Project Management, 28(3), 201-211.

Chua, D. K. H., and Godinot, M. (2006). "Use of a WBS Matrix to Improve Interface Management in Projects." Journal of Construction Engineering and Management, 132(1), 67-79.

Cohenca-Zall, D., Laufer, A., Shapira, A., and Howell, G. A. (1994). "Process of planning during construction." Journal of Construction Engineering and Management, 120, 561.

Construction Industry Institute. (1994). Pre-Project Planning: Beginning A Project the Right Way. Research Summary 39-1.Construction Industry Institute. Austin. TX.

Construction Industry Institute. (1999). Pre-Project Planning Tool: PDRI for Buildings. Research Summary 155-1.Construction Industry Institute. Austin. TX.

Construction Industry Institute. (2003a). The Owner's Role in Construction Safety. Research Summary 190-1. Construction Industry Institute. Austin. TX.

Construction Industry Institute. (2003b). Benchmarking & Metrics Value of Vest Practices Report. BMM 2003-4. Construction Industry Institute. Austin. TX.

Construction Industry Institute. (2006). The Owner's Role in Project Success. Research Summary 204-1. Construction Industry Institute. Austin. TX.

Construction Industry Institute. (2007). CII Benchmarking & Metrics Project Level Survey. Version 10.3. Construction Industry Institute. Austin. TX.

Construction Industry Institute. (2010). CII Value of Best Practices Report. BMM 2010-4. Construction Industry Institute. Austin. TX.

Construction Industry Institute. (2012). CII Best Practices Guide: Improving Project Performance. Implementation Resource 166-3. Ver. 4.0 Construction Industry Institute. Austin. TX

Critsinelis, A. (2001). "The modern field development approach." Proc., OMAE 20th Int. Conf. on Offshore Mechanics and Arctic Engineering., 391–400.

Crumrine, T., Nelson, R., Cordeiro, C., Loudermilk, M., and Malbrel, C. (2005). "Interface Management for Subsea Sand-Control-Completion Systems." SPE Latin American and Caribbean Petroleum Engineering Conference, 20-23 June 2005, Rio de Janeiro, Brazil.

Dayananda, D. (Ed.). (2002). Capital budgeting: financial appraisal of investment projects. Cambridge University Press.

de Vaus, D. (2001). Research Design in Social Science. Sage Publication.

de Vaus, D. (2002). Analyzing social science data: 50 key problems in data analysis. Sage Publication.

Engineering New Record. (2009). "The Top Owners Sourcebook." Engineering New Record, McGraw Hill Construction.

Engineering News Record. (2010). "The Top Owners Sourcebook." Engineering New Record, McGraw Hill Construction.

Fortune, J., and White, D. (2006). "Framing of project critical success factors by a systems model." International Journal of Project Management, 24(1), 53-65.

Healy, P. L. (1997). Project Management: Getting the job done on time and in budget, Butterworth-Heinemann.

Hinze, J., and Tracey, A. (1994). "The Contractor-Subcontractor Relationship: The Subcontractor's View." Journal of Construction Engineering and Management, 120, 274.

Hundertmark, T., do Valle Silva, A. O., and Shulman, J. A. (2008). "Managing capital projects for competitive advantage." The McKinsey Quarterly, June.

Kerzner, H. R. (1992). Project management: a systems approach to planning, scheduling, and controlling. 4th ed. Wiley.

Kerlinger, F. N. (1986). Foundations of Behavioral Research, (3rd ed.) New York, Holt, Rinehart and Winston.

Khanzode, A., Fischer, M., and Hamburg, S. (Year). "Effect of Information Standards on the Design/Construction Interface: Case Examples from the Steel Industry." Proceedings of the Eighth International Conference on Computing in Civil and Building Engineering, ASCE.

Kumar, R. (1999). Research methodology. Sage Publications.

Lin, Y.-C. (2009). "Developing Construction Network-Based Interface Management System." Building a Sustainable Future, ASCE, Seattle, Washington, 49-49.

Mehta, C. R., & Patel, N. R. (1989). IBM SPSS Exact Tests.

Miles, R. S., and Ballard, G. (2002). "Problems in the interface between mechanical design and construction: a research proposal." Journal of Construction Research, 3(1), 83-95.

Morrow, E. W. (2011) Industrial Megaprojects: Concepts, Strategies, and Practices for Success. John Wiley & Sons.Mehta and Petal

Nooteboom, U. (2004). "Interface management improves on-time, on-budget delivery of megaprojects." JPT Online.

National Resaerch Council. (2002). Proceedings of government/industry forum: the owner's role in project management and preproject planning, National Academies Press, Washington D.C.

National Research Council. The Owner's Role in Project Risk Management. Washington, DC: The National Academies Press, 2005

O'Brien, M. J., Wakefield, R., and Beliveau, Y. (2000). Industrializing the residential construction site, U.S. Dept. of Housing and Urban Development

O'Brien, M. J., and Willmott, A. A. (Year). "Planned inspection and maintenance." The Whole-life Performances of Facades Proc., Univ. of Bath, Bath, U.K.

O'Connor, J. T., Rusch, S. E., and Schulz, M. J. (1987). "Constructability concepts for engineering and procurement." Journal of Construction Engineering and Management, 113, 235.

Pavitt, T. C., et al. (2001). "CladdISS—A strategy for managing cladding interfaces." Proc., ICBEST, Int. Conf. on Building Systems and Technology.

Pavitt, T. C., and Gibb, A. G. F. (2003). "Interface Management within Construction: In Particular, Building Facade." Journal of Construction Engineering and Management, 129(1), 8-15.

Pitagorsky, P. (1998). "From My Experience The Project Manager/Functional Manager Partnership." Project Management Journal, 29, 7-16.

Pocock, J. B., Hyun, C. T., Liu, L. Y., and Kim, M. K. (1996). "Relationship between project interaction and performance indicators." Journal of Construction Engineering and Management, 122, 165.

Pocock, J. B., Liu, L. Y., and Kim, M. K. (1997). "Impact of Management Approach on Project Interaction and Performance." Journal of Construction Engineering and Management, 123(4), 411-418.
Project Management Institute. (2008). A Guide to the Project Management Body of Knowledge: PMBOK® Guide. Project Management Institute.
Shrive, C. A. (1992). “Specifying for multiple prime contracts.” Construction specifier, Construction Specifications Institute, Alexandria, VA.
Sozen, Z. (1996). "Management of transactions: The design/construction interface." Journal of Architectural and Planning Research, 13(1), 43-49.
Srivannaboon, S. (2006). "Linking project management with business strategy." Project Management Journal, 37(5), 88-96.
Stuckenbruck, L. C. (1988). Integration: The essential function of project management. Project management handbook, 56-81.
Suk, S.J. (2012). Analysis of Project Management Attributes for the Successful Delivery of Capital Facility Projects. UT Austin. Austin. TX.
Sundgren, N. (1999). "Introducing interface management in new product family development." Journal of Product Innovation Management, 16(1), 40-51.
Wright, J. N. (1997). Time and budget: the twin imperatives of a project sponsor. International journal of project management, 15(3), 181-186.
Xu, J., Liu, Z., Li, Y., and Wang, X. (2007). "Risk Identification of Logistics Outsourcing Based on Interface Management." Proceedings of the First International Conference on Transportation Engineering 2007 (ICTE 2007), ASCE.
Zwikael, O. (2008). "Top management involvement in project management: Exclusive support practices for different project scenarios." International Journal of Managing Projects in Business, 1(3), 387-403.

Vita

Sungmin Yun was born in Mokpo, Korea, on July 2, 1978, the son of Kyu-Hyun Yun and Hoo-Yeop Park. He attended Chonnam Science High School and graduated in February 1997. In March of 1997, he entered Yonsei University in Seoul, Korea. From March 1999 to May 2001, he fulfilled his military duty. He received a Bachelor of Science in Civil Engineering from Yonsei University in February 2004. After finishing undergraduate, he continued to graduate studies in Civil Engineering with a specialization in Construction Management & Information at the same university. He earned his Master of Science in Civil Engineering in February 2006. After finishing his master's degree, he worked in Infrastructure & Construction Economics Division at Korea Research Institute for Human Settlements as an assistant research fellow from March 2006 to May 2007.

In August 2007, he enrolled in Construction Engineering and Project Management at the University of Texas at Austin to pursue Ph.D. degree. Since 2008, he has worked with the Benchmarking & Metrics (BM&M) team at the Construction Industry Institute (CII). At CII, he was an Account Manager responsible for general benchmarking program, productivity benchmarking program, and various performance assessment studies.

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