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  - The specific knowledge module that the case addresses (see link above)
  - Learning objectives
  - Relevant theoretical concepts or models that can be applied
  - Research methodology
  - Discussion questions with suggested responses
  - A teaching plan, if not inherent in the Q&A section
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Agile Methods on Large Projects in Large Organizations

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ABSTRACT

Agile methods have taken software development by storm but have been primarily applied to projects in what is referred to as the “agile sweet spot,” which consists of small collocated teams working on small, non-critical, green field, in-house software projects with stable architectures and simple governance rules. These methods are being used more and more on large projects, but little documentation is available in the academic literature. This article investigates the adoption and adaptation of agile methods for use on large projects in large organizations. The empirical study is based first on case studies, followed by a survey to validate and enrich the case study results. The results are somewhat paradoxical in that some features are common to almost all observations, whereas others show extreme variability. The common features include use of Scrum methodology and agile coaches, as well as the non-respect of the agile principle of emergent architecture.

KEYWORDS: agile; scale; Scrum; traditional; flexibility

INTRODUCTION

Agile methods have taken software development by storm since the publication of the Agile Manifesto. In recent years, agile methods have become highly prevalent in the software industry (Abrahamsson, Conboy, & Xiaofeng, 2009; Dingsøyr, Nerur, Balijepally, & Moe, 2012) and today, it is one of the hottest topics in project management. Project Management Institute has created the PMI Agile Certified Practitioner (ACP)® certification, and Project Management Journal® will be publishing a special issue on the topic in the future.

Although there have been multiple attempts to apply agile principles to non-software projects (Conforto, Salum, Amaral, da Silva, & de Almeida, 2014; Highsmith, 2003; Petit & Levesque, 2015), current research is limited to the field of software development, the field in which agile methods have become prominent; it focuses on two levels of analysis: the individual project and the organizational context in which projects are carried out. The agile literature has focused almost exclusively on the former while almost completely ignoring the latter (Dingsøyr et al., 2012).

The advantages of using agile methodologies identified in the literature include: a working environment that supports creativity and productivity, rapid adaptation to change, and value for the customer because of the improved identification of needs and priorities and faster multiple deliveries of functionalities (Schwaber, 2004; Thomke & Reinertsen, 1998). These advantages are more readily obtained with certain types of projects in certain contexts (Boehm & Turner, 2005). Leffingwell (2010) showed that there are a number of impediments to the scaling of these practices in large multi-site, multi-customer, and multi-project organizations. During preliminary interviews prior to undertaking this research, the authors discovered several large organizations that had been experimenting with agile methods over a period of five years or more and that these organizations are struggling to scale from a few agile teams to an organization-wide implementation of agile methods. These observations are consistent with the results of a survey of 3,880 participants, in which VersionOne (2016) found that organizations are continuing to scale agile beyond single teams and single projects and that more energy is being put into scaling agile across the enterprise. The overall objective of this research is
to fill this gap by examining projects and contexts that are not in the agile sweet spot, specifically large software projects in large organizations.

The research questions at the project level are: What challenges are encountered when applying agile methods to large multi-team software projects and what practices have been developed to alleviate these challenges? The literature that has examined these questions has most often taken an approach that contrasts and/or mixes agile and traditional project management approaches (Boehm & Turner, 2003, 2004, 2005; Conforto et al., 2014; Sommer, Hedegaard, Dukovska-Popovska, & Steger-Jensen, 2015; Špundak, 2014). This research aims to go beyond this somewhat simplistic approach based on a rich description of practice in specific contexts.

At the organizational level, this research examines the implementation of agile methods in large organizations as it has unfolded over time by tracking implementation strategies and successive adaptations. The adoption of agile methods by a large complex organization requires experimentation and adaptation of the methods to the organization’s structure, culture, product/service strategy, human resource management policies, customer interfaces, project roles and governance structures, including program and project portfolio management. At the same time, the organizational context is influenced by the implementation of agile methods. The research question at the organizational level is:

How does the context of large complex organizations affect the adaptation and adoption of agile methods and vice versa?

For a complete research report, including the survey instrument see Hobbs and Petit (in press).

**Literature Review**

**Agile Approaches**

Agile methodologies are specific approaches, designed in response to the specific challenges of the software industry (i.e., high uncertainty, short development cycle, no physical deliverable) and used to implement flexibility in the project management process (Agile Alliance, 2001; Lindvall et al., 2004).

Agile approaches are best defined by Scott W. Ambler (2009) as:

“Agile software development is an evolutionary (iterative and incremental) approach which regularly produces high quality software in a cost effective and timely manner via a value driven lifecycle. It is performed in a highly collaborative, disciplined, and self-organizing manner with active stakeholder participation to ensure that the team understands and addresses the changing needs of its stakeholders. Agile software development teams provide repeatable results by adopting just the right amount of ceremony for the situation they face.” (p. 6)

Conboy (2009) conceptualizes the agile approach from two related concepts: flexibility and leanness—two concepts inspired from the flexible mass production systems led by the Toyota production system since the 1950s. Conforto, da Silva, Di Felippo, and Kamikawachi (2016) analyzed 59 definitions covering the concept “agile.” They propose a comprehensive definition of the agility construct covering: the entity, the event, the degree, the trigger, the purpose, and the circumstances, as follows: “Agility is the project team’s ability to quickly change the project plan as a response to customer or stakeholders’ needs, market or technology demands in order to achieve better project and product performance in an innovative and dynamic project environment.” All agile approaches share common values and principles, as stated in the Agile Manifesto (Agile Alliance, 2001) and subsequent publications by authors of the Manifesto (Highsmith, 2010; Levin, 2012; Schwaber, 2007). Of these methods, Scrum (Schwaber, 2004; Schwaber & Sutherland, 2013) and Extreme Programming (XP) (Beck, 2000), are by far the best-known and most widely used.

**Agile and Traditional Project Management Approaches**

Agile approaches are often presented in opposition to the more traditional project management principles and practices (Fernandez & Fernandez, 2008). For example, the Agile Manifesto (Agile Alliance, 2001) proposes four core values and twelve principles, which are presented in opposition to the traditional software development project values (for example, “Responding to change over following a plan”). This opposition is particularly relevant when agile is introduced in large organizations where established processes and project management practices are already in place. Boehm and Turner (2005) simply question: “How do you merge agile, lightweight processes with standard industrial processes without killing agility?” (p. 31)

Some authors recommend a balanced combination of plan-driven traditional project management and an agile approach to managing projects, stating that the flexibility of an agile approach should be balanced with the advantage of a more traditional approach through a risk-based analysis (Al-Zoubi, 2008; Boehm, 2002; Boehm & Turner, 2003, 2004). Anantatmula and Anantatmula (2008) show empirically that such a combined approach may be very valuable for the management of projects in an IT environment. It has also been shown that agile methods could be combined with stage-gates in large organizations (Karlstrom & Runeson, 2005). This might lead to a different combination and alignment of the software development phases with the project management phases. Another option, according to Vinekar, Slinkman, and Nerur (2006), would be to have both the traditional and the agile methodologies co-exist in separate subunits within an ambidextrous organization. The issue then becomes to develop criteria for selecting which method to use on each project (Barlow et al., 2011); adoption of one method over the other would often be based on the organization’s
Scaling Agility (or not)

Although agile methodologies have provided flexibility in the software development process, most benefits have been achieved with small projects composed of one or a few dedicated self-managed teams (Kruchten, 2013). For some organizations, the issue might become whether or not to adopt agile approaches, considering the size and legacy of their systems and practices. Kruchten attempts to answer this dilemma by proposing some scaling factors, which might distinguish the contexts in which agile might be easier to introduce than others.

There has been very limited research on the topic of large-scale software development projects using agile approaches (Dyba & Dingsøyr, 2008; Razavi & Ahmad, 2014), although a number of specific cases have been investigated, for example, in the oil industry (Grewal & Maurer, 2007); in large software and product development organizations (Gruver & Mouser, 2015; Lindvall et al., 2004; Mahanti, 2016); in regulated environments (Fitzgerald, Stol, O’Sullivan, & O’Brien, 2013); and at BMC Software Infrastructure (Gat, 2006). In these cases, the level of scaling varies significantly (in terms of project size, number of teams, and number of sites). To help categorize the varying levels of scaling, Dingsøyr et al. (2014) suggest a taxonomy of scale of agile software development projects based on the number of teams, where small-scale corresponds to one team, large-scale to two to nine teams, and very large-scale to more than ten teams. Based on this scale, the main focus was on large-scale projects using agile in this research.

Challenges Facing Large Organizations Trying to Implement Agile Approaches

While agile methodology seems suited for small colocated teams in which the customer can be directly involved, there are a number of impediments to the scaling of these practices in large multisite, multi-customer, and multi-project organizations. At the 2004 University of Southern California Center for Software Engineering (USC-CSE) Annual Research Review, Boehm and Turner (2005) identified some of the challenges to implementing agile processes in traditional development organizations. The result was a collection of change-related challenges and a list of nearly 40 perceived barriers to agile implementation in large organizations. Many of these challenges were related to scope or scale, but some were related to the clash between the agile and traditional cultures; for example, development process conflicts, variability in subsystems developed that might not integrate easily, different life cycles, and difficulty in using agile on legacy systems.

Leffingwell (2007) groups the challenges of scaling agile into two broad categories: (1) those inherent to the methods themselves, “because of the fixed rule bases and assumptions built into the methods” (p. 87); and (2) challenges imposed by the enterprise that “will prevent the successful application of the new methods” (p. 87). Included in the first category are challenges such as: number and size of teams, difficulty in making the customer an integral part of the team, collocation, emergence of the architecture, lack of requirements analysis, and documented specifications. The impediments related to the enterprise would include: clashes with the existing process and project management organizations, existing formalized policies and procedures, corporate culture, fixed schedule/fixed functionality mandates, and people organized by discipline rather than product line. Mahanti (2006) found similar challenges adopting agile practices in large organizations but identified the prime challenge as the integration of agile projects with the project environment’s existing processes.

Scaling Frameworks

The literature on scaling agile has been dominated by consultants proposing a number of frameworks (Agilealliance.org) developed in recent years to facilitate the use of agile principles in larger projects. According to the survey performed by VersionOne (2016), the most commonly used isScaled Agile Framework (SAFe®), which has evolved from the Rationale Unified Process (Leffingwell, 2015). Scott W. Ambler (2009) initially proposed a scaling model, called Agile Scaling Model (ASM), which evolved into the framework called Disciplined Agile Delivery (DAD) (Scott W. Ambler & Lines, 2014; DAD—Disciplined Agile Delivery, 2015). Under this model, projects can be scaled based on factors such as team size, geographical distribution, regulatory compliance, domain complexity, organizational distribution, technical complexity, organizational complexity, and enterprise discipline. Other recent frameworks include: Large-Scale Scrum (LeSS) (Larman, 2015; Larman & Vodde, 2014), and Nexus (Schwaber, 2015). All these frameworks attempt to preserve the benefits of agile while improving the links to larger organizations (Gruver & Mouser, 2015). Because of their recent introduction on the market, it is very difficult to assess whether these frameworks have indeed properly addressed some of the issues related to scaling agility and how organizations are actually implementing them.

Investigating the Use of Agile in Large Projects and Large Organizations

Little has been reported in the literature on the interplay between agile methods and the accompanying organizational arrangements (Kettunen, 2007). However, Kettunen (2009) suggests that further improvements in software development could be inspired by organization-oriented business concepts, such as concurrent engineering, multi-project management, and being proactive.

At the XP 2010 conference in Trondheim, Norway, practitioners were polled on what they felt should be the most relevant research topic in their fields. The topic of “agile and large projects”
Agile Methods on Large Projects in Large Organizations

came first on the list (Freudenberg & Sharp, 2010). The exercise was repeated in 2013 and Scaling Agility once again came among the top topics of interest (Dingsøyr & Moe, 2013). This is consistent with the assessment of Ågerfalk, Fitzgerald, and Slaughter (2009), who suggested two of the top research topics in flexible and distributed information system (IS) development should be: (1) organizational selection, adoption, and adaptation of agile methods and (2) agility at the organizational level. It is the ambition of this research to fill this gap in the research on these two topics.

**Methodology**

Little is known about the subjects investigated in this research and for this reason, the study is exploratory. The research was conducted in two phases. During the first phase, qualitative case studies were conducted. The second phase was a survey to confirm and enrich the results of the case studies. The research can, therefore, be said to employ a mixed method (Tashakkori & Teddlie, 1998). A total of 48 substantially complete responses to the survey were received. The respondents were 44 years of age with 5.6 years of experience with agile methods. Their current roles vary a great deal—in decreasing order of prevalence they are: program managers, IT managers, project managers, ScrumMasters, agile coaches, business or product unit managers, portfolio managers, business analysts, product owners, technical leads, and one software factory director. The respondents come from a diversified group of experienced practitioners. A sample of 48 responses is too small to support most multivariate analyses. The results from the case studies and the survey are very consistent. In addition, the survey results quantify the trends observed in the case studies. The consistency between the results from the two phases is indicative of the generalizability of the results. Comparison with another recent survey by VersionOne (2016) (N = 3,880) with several similar questions reveals that respondent demographics, the descriptions of the implementation of agile methods, the benefits derived for the use of agile methods, and the obstacles to implementation were very similar. The similarities indicate that the 48 responses to the survey in this research are representative of a larger population. Note that the survey in this research contained several questions not included in the VersionOne survey; however, further research with larger sample sizes would be necessary to validate the generalizability of the results presented here.

**The Qualitative Case Studies**

Large organizations doing several large software projects were investigated. These types of organizations were chosen because they are ideal sites for exploring the use and impact of agile methods outside of the agile sweet spot at both the project and organizational levels. One of the central features of agile methods is the presence of customer representatives in the role of product owner. This is also one of the problematic features in the application of agile methods in large organizations; for this reason, organizations with different types of relationships with customers were investigated. The customers vary in two important dimensions: number of customers and internal versus external customers.

Three case organizations were used to explore both the project and organizational levels of analysis. In each organization, interviews and analyses of documents were the primary sources of data. Interviews were conducted at both the organizational and project levels. The people targeted for organizational level interviews included members of senior management, program and portfolio managers, directors of project management offices, champions of agile methods, and line managers. The people targeted for project level interviews included ScrumMasters, product owners, project managers, analysts, and system architects. An interview guide was prepared based on previous work (Petit & Besner, 2013), the literature review, and the research questions. The questions asked during the early part of the interview were open-ended. The interview guide provided a list of information that should be collected during the interview, but not a list of questions to be asked directly except as follow-up questions as the interview progressed. The interview guide was tested during several interviews and revised accordingly. Data relative to each level of analysis (project versus organizational) were provided in many of the interviews. The separation by level of analysis was, therefore, carried out during the analysis of the interviews. All interviews were recorded, transcribed, and analyzed using ATLAS Ti software.

The original research design called for the analysis of three projects composed of three or more development teams in each of three case study organizations. These were carried out in a financial services company, a company producing large complex systems they sell to outside customers, and a public organization. A total of 41 interviews, with an average duration of one hour, were conducted. The interviewees are presented in Table 1.

The analysis of the nine projects in three case study organizations revealed a very high level of variability in the organizations’ contexts and histories, the organizational arrangements and role definitions that accompanied the implementation of agile methods, and the management practices that were put in place on each of the projects investigated. The analysis of the three case studies provided a good understanding of these organizations. However, it was not clear to what extent they were representative; in other words, the authors did not feel that the saturation point had been reached in the interviews (DiCicco-Bloom & Crabtree, 2006). For this reason, three additional 90-minute interviews were conducted with key informants in three additional organizations. The three organizations...
were selected to be in industries similar to the initial cases (i.e., financial services, large system development, and the public sector). The complementary interviews investigated the level of the organization and one specific large project, for an overall total of twelve projects in six organizations. The interviews were again recorded, transcribed, and analyzed using ATLAS Ti. In two of the organizations, one key informant was interviewed. In the third organization, two informants participated in one interview. There were many similarities and several significant differences between the six organizations investigated. After examining the interviews, the understanding of the use of agile methods on large software projects in large organizations was deemed sufficient to adequately support the preparation of the survey for phase two, because that saturation point had been reached.

The Survey Instrument

The survey instrument requested the participation of practitioners who were able to provide a high-level description of a software development project with at least three development teams carried out in an organization with at least 2,000 employees. However, two responses with 1,600 and 1,652 employees, respectively, were retained in the sample. Three development teams are sufficient to produce coordination challenges not found with a single team. The minimum number of three development teams was based on the results of the analysis of the projects in the six organizations that participated in phase one and contact with the agile community of practice over several years, which showed that projects with significantly more than three development teams are relatively rare. Setting the minimum number of employees at 2,000 was somewhat arbitrary, but the researchers are aware that agile methods are used primarily in small organizations and that setting the limit higher would make it difficult to gather sufficient survey data. An organization with 2,000 employees is large enough to have the effects of specialization and formalization that characterize large organizations (Mintzberg, 1979). The survey instrument, which includes 91 questions, is available in the research monograph (Hobbs & Petit, in press). Due to spatial constraints, the full questionnaire could not be included in this article. A summary description of the survey instrument is provided in Table 2.

Data Collection and Analysis

Invitations to participate in the survey were distributed through several channels. The Project Management Institute provided logistical support for distribution. Invitations were also distributed through two decentralized international networks of groups dedicated to agile methods (Agile Tours and Agile Alliance). These communities organize annual conferences under the brand “Agile Tour,” including the agile community of practice in the authors’ home city, which collaborated in this research. Invitations were also distributed using social media and the authors’ personal networks. A total of 48 substantially complete responses to the survey were received. All of the case study organizations and the majority of the organizations of the survey respondents use agile methods in contexts in which traditional software project management methods are well established. However, a minority of survey respondents reported on contexts in which all software development projects employ agile methods. Respondents in contexts in which both traditional and agile methods are employed responded to the final section of the survey questionnaire. The objective of this section is to investigate the process by which agile methods have been implemented into contexts dominated by traditional methods and investigate how organizations allocate projects to traditional and agile methods. This section of the survey also investigated the impact of the

<table>
<thead>
<tr>
<th>Large System</th>
<th>Financial</th>
<th>Public</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of interviews</td>
<td>Average Duration (minutes)</td>
<td>Number of interviews</td>
<td>Average Duration (minutes)</td>
</tr>
<tr>
<td>Project Manager</td>
<td>5</td>
<td>65.6</td>
<td>2</td>
</tr>
<tr>
<td>Scrum Master</td>
<td>2</td>
<td>41.5</td>
<td>5</td>
</tr>
<tr>
<td>Product Owner</td>
<td>1</td>
<td>68</td>
<td>3</td>
</tr>
<tr>
<td>Executive</td>
<td>1</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>PMO or Portfolio Manager</td>
<td>2</td>
<td>46.5</td>
<td>2</td>
</tr>
<tr>
<td>Analysts</td>
<td>1</td>
<td>56</td>
<td>1</td>
</tr>
<tr>
<td>Line Manager</td>
<td>1</td>
<td>66</td>
<td>1</td>
</tr>
<tr>
<td>Architect</td>
<td>1</td>
<td>49</td>
<td>6</td>
</tr>
<tr>
<td>Total / average</td>
<td>12</td>
<td>57.25</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 1: Summary of interviews from nine projects in three organizations.
Agile Methods on Large Projects in Large Organizations

Section 1. Respondent demographics

Section 2. The relevant organizational context:

a. Which in most cases is only a part of the organization, a division or subsidiary, for example
b. The years when agile methods were used for the first time on small projects and on large projects. From the case studies and a general knowledge of the context it is known that many organizations, but not all, implement agile methods first on small projects.
c. The level of maturity in the use of agile methods
d. The presence of an agile community of practice
e. The total number of projects and the proportion employing agile methods

Section 3. A specific large project that employed agile methods:

a. The level of knowledge of agile methods of people involved in this project
b. Types of deliverable, scope, and duration
c. Level of integration with other systems
d. Number and duration of sprints
e. Project organization:
   i. Number and composition of development teams
   ii. Other teams or committees
   iii. Other individuals
f. Project initiation, activities related to architecture and to the planning of sprints before the beginning of software development per se, often referred to as sprint zero
g. Agile practices employed
h. Benefits and disadvantages of agile methods and project performance

Section 4. The transition from traditional methods to agile methods.

From a general knowledge of the field, it is known that most large organizations had well-established traditional project management methods prior to implementing agile methods and that in most cases the two are present. However, some organizations use agile methods exclusively. For these reasons, section four of the survey was completed only by respondents in contexts where both methods are currently in use.

a. Decision rules for determining which projects use agile methods
b. Performance objectives that motivated use of agile methods
c. Organizational objectives that motivated use of agile methods
d. Strategy for implementing agile methods, including change management
e. Organizational characteristics that supported implementation
f. Organizational characteristics that are obstacles to implementation
g. Performance outcomes
h. Organizational change outcomes
i. New and changed organizational roles, particularly for project managers, ScrumMasters, and product owners

Table 2: Survey questionnaire (overview).

introduction of agile methods in organizations with well-established traditional methods. A total of 35 responses to this final section were received; the remaining 13 respondents, or 27%, are in contexts in which all projects are managed using agile methods.

The Case Study Organizations

All of the case study projects developed and/or made significant changes to large complex systems with multiple interconnections to adjacent systems. All six organizations have introduced agile methods into a context in which well-established traditional project management methods are in place.

The two financial services companies have formalized structures and procedures and a high degree of specialization. The business processes in this type of organization make extensive use of complex computer systems, which are interconnected internally and with other organizations, including customer organizations and suppliers of information. The software projects are all related to the development and/or updating of systems used by operational employees of the company, by employees in other organizations that are connected to their systems, and by online customers. In this type of organization, internal business units are the project customers from which product owners are drawn. However, as stated in the literature and shown in the results of this research, the role of product owner is problematic. Financial services is an important sector in which large-scale agile projects are found; 26% of the respondents to the survey are from this sector and it is the second most common industry after software reported in the VersionOne (2016) survey.
The two companies that produce large complex systems that are sold to other organizations for use in their internal business processes have very different relationships with their end users. The product is used by multiple independent customer organizations, which are often in competition with each other. In addition, the contractual process through which the product is sold often specifies what is to be delivered in rather precise detail, which introduces rigidities difficult to reconcile with the flexibility of agile methods and the idea of updating and reprioritizing the product backlog continuously. In these two companies, the product owner role is filled by product managers with the authority and the interest in directing product development.

The systems in the two public sector organizations are numerous, large, interconnected internally and with other organizations, many of which are also in the public sector, but not all. The information technologies in these two organizations are very different. One has many large, poorly performing legacy systems based on outdated technology. The tight integration of the systems, the specialization of both people and organizational units, and the activities used to integrate and test all changes before the infrequent releases into production, all create obstacles to the use of agile methods. The organization has a plan to update its databases and systems with a view to making them less tightly integrated and more amenable to more frequent releases.

The other public sector organization has up-to-date technology. The part of the organization investigated is responsible for a shared communication channel facilitating communication between software modules, and the end users are internal to the organization. The challenge in this organization is to respond more quickly and more adequately to priority system development requests.

The literature on agile methods claims that these methods provide many performance advantages when compared with traditional methods (Dubey, Jain, & Mantri, 2015; Serrador & Pinto, 2015; Sheffield & Lemétayer, 2013; Stoica, Mircea, & Ghilic-Micu, 2013). According to the respondents, the organizations met the performance objectives, which justified the decision to use agile methods.

In addition to the performance objectives (such as improved speed and quality), organizations are also pursuing organizational change objectives. Both the interviews and survey report that the following organizational change objectives are both used to justify the use of agile methods and realized during implementation. The objectives are presented in decreasing order of mention in Table 3 and are based on Sections 4a, b, and c of the survey.

All the organizational change objectives reported in both the interviews and the survey, with the exception of improved software engineering practices, are inter-related. Together they represent significant changes in the organizational culture, the working climate, and leadership.

Note that in some of the case study organizations and in the survey data, improved software engineering practices is one of the organizational change objectives. This is the case in which the poor performance of traditional methods is one of the justifications for using agile methods. Software engineering practices are not directly related to agile methods; however, the agile principle that “Continuous attention to technical excellence and good design enhances agility” (Agile Alliance, 2001) can be seen to imply a link between software engineering excellence and agile methods. It is reasonable to assume that improved software engineering practices are at least in part responsible for the performance improvements associated with the change. In these situations, agile methods seem to benefit from performance improvements.

### Table 3: Objectives of implementing agile

<table>
<thead>
<tr>
<th>Objective</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved collaboration between development teams.</td>
<td>59%</td>
</tr>
<tr>
<td>Better communication and understanding between developers and end users.</td>
<td>55%</td>
</tr>
<tr>
<td>Better collaboration among organizational units.</td>
<td>50%</td>
</tr>
<tr>
<td>Improved satisfaction of personnel.</td>
<td>44%</td>
</tr>
<tr>
<td>Empowerment of personnel.</td>
<td>39%</td>
</tr>
<tr>
<td>Improved software engineering practices.</td>
<td>37%</td>
</tr>
<tr>
<td>Better organizational climate.</td>
<td>35%</td>
</tr>
<tr>
<td>Increased motivation and commitment of personnel.</td>
<td>33%</td>
</tr>
<tr>
<td>Change from command and control to servant leadership.</td>
<td>26%</td>
</tr>
</tbody>
</table>

### Results

The results presented here are based on the qualitative case studies, complemented by references to results from the survey questionnaires. The information from the qualitative case studies and the information from the survey are very consistent. The consistency indicates that the case study results are representative of trends that go beyond the six case study organizations. However, an accurate measure of the extent to which they are generalizable would require a much larger sample. The results are presented in four groups: (1) motives and strategies for implementing agile methods, (2) the impact of agile implementation on organizational roles, (3) the impact of agile implementation on project initiation, and (4) agile project organizations.

#### Motives and Strategies for Implementing Agile Methods

**Motives for Implementing Agile Methods**

The literature on agile methods claims that these methods provide many performance advantages when compared with traditional methods (Dubey, Jain, & Mantri, 2015; Serrador & Pinto, 2015; Sheffield & Lemétayer, 2013; Stoica, Mircea, & Ghilic-Micu, 2013). According to the respondents, the organizations met the performance objectives, which justified the decision to use agile methods.

In addition to the performance objectives (such as improved speed and quality), organizations are also pursuing organizational change objectives. Both the interviews and survey report that the following organizational change objectives are both used to justify the use of agile methods and realized during implementation. The objectives are presented in decreasing order of mention in Table 3 and are based on Sections 4a, b, and c of the survey.

All the organizational change objectives reported in both the interviews and the survey, with the exception of improved software engineering practices, are inter-related. Together they represent significant changes in the organizational culture, the working climate, and leadership.

Note that in some of the case study organizations and in the survey data, improved software engineering practices is one of the organizational change objectives. This is the case in which the poor performance of traditional methods is one of the justifications for using agile methods. Software engineering practices are not directly related to agile methods; however, the agile principle that “Continuous attention to technical excellence and good design enhances agility” (Agile Alliance, 2001) can be seen to imply a link between software engineering excellence and agile methods. It is reasonable to assume that improved software engineering practices are at least in part responsible for the performance improvements associated with the change. In these situations, agile methods seem to benefit from performance improvements.
that are at least in part attributable to improvements in software engineering practices that could have been implemented without the implementation of agile methods. It is plausible that the momentum of the change to agile methods, with significant support from upper management, made improvements in software engineering practices easier to implement. It is also plausible that the frequent integration, tests, and demos created an environment that fosters improvements in the quality of the code.

In several of the case studies, the change to agile methods was motivated in part by the demands of young qualified software developers. In labor markets where the demand for qualified developers exceeds the supply, these workers can be considered volunteer labor in that they can choose the place where they work. In these situations, being able to provide a suitable working environment may provide organizations with a competitive advantage in that they are better able to recruit and retain qualified personnel.

**Implementation Strategies**

The implementation strategies of all six case study organizations and 74% of the organizations of survey respondents started with pilot projects. All of the development teams in the case studies and all but one in the survey had agile coaches. The role of the agile coaches was primarily to support the implementation of Scrum on development teams; however, the implementation strategies have very little else in common. The extent to which agile methods have become well-established in these six organizations varies a great deal. The six organizations are presented in approximately decreasing order of the extent to which agile methods are well established.

One of the organizations experimented with agile methods on small projects in one department between 2007 and 2009 and deployed these methods on all their software development projects between 2010 and 2013. Agile methods on both large and small software development projects are now well-established throughout the firm. The other five organizations are in the early stages of implementation, particularly for large projects. A second organization has been using agile methods on small projects for five years and just completed one large and very successful project using agile methods. Agile methods are well on their way to becoming well established for both large and small projects in this organization. A third organization is the IT department of a public organization composed of approximately 250 people, where agile was introduced following years of unsuccessful projects for which traditional methods were used. This organization was one of the case studies in which a scaling framework was used—a mixture of Nexus and LeSS. Their goal is to gradually move away from project development to more continuous deliveries using a central databus (i.e., a shared communication channel facilitating communication between software modules). In a fourth organization, agile methods are currently being applied for the first time on pilot projects. The implementation is being sponsored by the CEO and the board of directors in response to an external audit, which showed that both the organization’s software development projects and its legacy systems are performing very poorly. A new vice president and a new senior manager have been brought in to manage the implementation process. Contrary to recommendations in the literature (Kruchten, 2013) and the practice in most other organizations, they have selected large projects as the pilots for implementation. The strategy is to show that agile methods can be applied to large projects and to demonstrate the commitment of upper management to the large-scale conversion to agile methods. At the time of the interviews, the pilot projects had been underway for two years. The pilot projects are well along the learning curve that accompanies change in the organization and in methods, and several indicators show that the performance of the pilot projects is meeting expectations. It seems likely that upper management will continue to support the large-scale conversion to agile methods in this organization. The fifth organization implemented agile methods on one large project between 2008 and 2012. This organization is a small R&D and product development unit of a large multinational firm. In this organization, the project was very successful and might have led to further use of agile methods in this unit, but due to an unrelated reorganization of the multinational firm, several small R&D units were closed, including this one. It is not possible to know what impact this experiment has had if any. In the final organization, several small projects have been completed using agile methods since 2005. The early pilots were the results of local and personal initiatives. Initially, a set of rules was used to determine whether to use agile or traditional methods; however, these rules were not formalized and, at the time of the interviews, the document containing the rules could not be located. In 2007, the CIO declared that all software development projects should use agile methods, but the resistance from the personnel in the IT department resulted in only a limited number of projects using agile methods. Agile methods were only used when a champion of these methods was on the team. People on other teams said that “agile methods are flexible, so we will be flexible and change agile methods to our liking.” Since they preferred traditional methods, there was little change. Many projects did analyze sprints, followed by development sprints, which were followed in turn by integration and test sprints. After a long series of sprints, a product could be demonstrated to customers and potentially released. In 2013, a new CIO put an end to the use of agile methods and returned to traditional methods. The case study projects in this organization were all initiated in the period prior to
2013. In the period following the interviews, a new CIO started to support local initiatives to use agile methods, in part because of the poor performance of traditional methods.

It is difficult to draw conclusions from a small sample, however, implementation in only one of the six organizations relied almost entirely upon initiatives by local champions, and this implementation has been unsuccessful over an extended period of time. The survey results also show that bottom-up implementation strategies are used infrequently (14% of responses). This implementation strategy might not lead to large-scale deployment as shown by the final case study. The survey results also indicate considerable variability: 33% of organizations implemented agile methods on large and small projects the same year, whereas the remaining organizations used agile methods on small projects for up to nine years before implementing them on large projects. The survey results also show a great deal of variation in the proportion of projects using agile methods in the organization: from 9% to 100%, with an average of 55%. It is clear that both the strategies for implementing agile methods and the success of implementation vary a great deal.

The Agile Sweet Spot
The fact that most organizations use agile methods on some projects but not all begs the question: What are the characteristics of projects selected for the use of agile methods? Kruchten (2013) identifies the conditions under which agile methods are easier to implement and produce better results more consistently. In several of the case study organizations, choices are being made as to which projects employ agile methods and which do not. During the interviews in these organizations, respondents were asked to identify the characteristics used to select projects for agile methods; none of these organizations had a clear policy regarding which projects should be done using agile or traditional methods. The survey results report that only 23% of organizations using both agile and traditional methods have a clear policy. It seems that in many cases the choice to use agile methods is influenced, to a considerable extent, by the personal preferences of managers and project personnel.

The Impact of Agile Implementation on Organizational Roles
The implementation of agile methods introduces many significant changes to the roles and responsibilities within the organization.

The Role of Project Manager
All the case studies and, all but one of the survey responses, show that the implementation of agile methods has a significant impact on the role of the project manager; they also show that the impact varies considerably from one organization to the next. The ScrumMasters and the self-organizing teams of the agile method have taken over the project manager’s responsibilities for the detailed planning of activities. The changes to the project manager’s role in the coordination of development teams show mixed results. In some cases, the coordination between teams is accomplished largely through the Scrum of Scrums, a regular meeting of the ScrumMasters, typically attended by the project manager. Note, however, that in a small number of cases, project managers are doing more to coordinate teams, a variability that merits further investigation. The project manager role is also reported to be more strategic and involve more effort in stakeholder management.

In one of the case study organizations, they experimented with the removal of the project manager role and concluded that, for small projects with only one development team, the project manager role could be filled by the ScrumMaster, but have elected to maintain the role modified for projects with several development teams. However, in another of the case study organizations, and in 6% of the survey responses, the project manager role has been eliminated. The implementation of agile methods can have a very significant impact on the role of the project manager, but a better understanding of the circumstances under which the project manager role changes and how it changes is needed.

The Role of ScrumMasters
The Scrum methodology was used in all the case study organizations. This is consistent with the dominant position of this methodology in the agile community worldwide (VersionOne, 2016). The ScrumMaster has a very central role in this method. All of the development teams in the case studies and all but one in the survey responses have ScrumMasters. The introduction of ScrumMasters is not problematic because a clear model for the role is well-established (Cohn, 2009; Schwaber, 2004, 2007; Sutherland, Viktorov, Blount, & Pintikov, 2007), resources for training and coaches are readily available, and a labor market of trained ScrumMasters exists. In many organizations, experienced ScrumMasters from small projects are available at the time large projects using agile methods are undertaken. In the case study organizations, the ScrumMasters had been mostly programmers/analysts or team leaders before becoming ScrumMasters. This is a major change, particularly for those who previously had a technical programmer/analyst role. The agile coaches work very closely with those responsible for planning and coordinating the team’s work as well as the team processes.

The Role of Product Owners
The archetype of the product owner as presented in the agile literature (Schwaber, 2004, 2007) is a person with both the knowledge and the authority to make changes to the product backlog and reprioritize at the beginning in each sprint. In this archetype, the product owner is available to development
Agile Methods on Large Projects in Large Organizations

In the reality of large-scale agile projects, the product owner does not always have the knowledge, authority, and availability portrayed in this archetype. The product owner role is problematic. Both the case study and the survey results show that the lack of understanding of this new role is the biggest challenge for product owners. In both the case studies and survey results, the level of knowledge of agile methods and the support for implementation are lower for business unit managers than for all other groups, including upper management.

The product owner needs to be available, knowledgeable of business needs, and have the authority to make decisions. All three of these characteristics pose problems. Making people with these characteristics available to development teams means making them less available for other roles within the business unit, which creates tension around the issue of their availability. In one of the case study organizations, the business units appoint people with very limited availability, business knowledge, and decision-making authority, which in turn causes delays in decisions and many referrals back to those in authority in the business unit, and results in additional delays. This is quite a hierarchical organization in which managers tend not to delegate very much. The role of product owner in agile methods is out of sync with this organization’s culture. In this case, the difficulties with the product owner role brought major differences between the agile culture and the host organization’s culture to the forefront.

The product owner represents the customer or the end user organization. A key part of this role is the identification and prioritization of the features in the product backlog at the end of each sprint. In traditional development there is no mechanism or incentive to make frequent and precise adjustments to priorities, but with agile methods these take place at the end of each sprint. The product owner role is radically different from the role of the customer organization in traditional development methods in which the customer specifies requirements and approves the scope at the outset, approves the project at milestones, makes changes, requests, and accepts the final product at project closure and commissioning. In traditional development, meetings between customer representatives and project representatives are infrequent and structured. The customer representative does not meet the members of the development team. In agile methods, the product owners are members of the project team who meet with the Scrum-Masters and development teams very frequently, at a minimum at the end of each sprint. In many cases, the product owners are full-time members of development teams.

Both the case studies and the survey show that a lack of decision-making authority is also a significant issue for a minority of product owners, and that most product owners need to address questions to the customer organization. Questions are submitted once a week on average and typically receive a reply within a few days; in a minority of organizations, however, the response time is much longer. In one of the case study organizations, a committee of managers from the business unit was set up to respond to such questions.

In cases in which the client is an internal business unit that will use the system in its internal operations, the product owner must know the business and is normally recruited internally. However, the role is different in situations in which the system is sold to organizations or people outside the company. In the two case study organizations in which the customer is external to the organization, the product owner role is filled by a product manager. There are challenges in this role, particularly when a well-specified product has been sold under contract or when a high profile customer makes very specific requests. In two of the case study organizations, the use of agile methods that require the product owner to update, groom, and reprioritize the product backlog had the effect of making the product manager much more responsive to requests for clear direction than had previously been the case.

In the case of systems sold outside the firm, there are additional problems. The marketing and product management departments have both the contact with and the knowledge of customers and markets. The ways in which these departments function traditionally is not in sync with agile methods, which are very flexible and refine priorities at the end of each sprint and frequently produce potential releases. Changing the functioning of the marketing and product management roles to be in better sync with the agile development methods is a major organizational change, the detailed study of which is outside the scope of this research and, to the best of our knowledge, has not been researched. One of the case study organizations is examining what this might entail; they refer to it as “agile end-to-end,” but it has yet to be implemented. A significant part of the problem is the fact that systems are sold under contract and that these contracts specify the scope and features of the systems to be developed and delivered. The question as to how to use the flexibility of agile to deliver systems specified by contract remains largely unanswered. The answer may lie with different types of contracts, but this would mean restructuring the industrial sector, which is neither simple nor without consequences.

In two of the case study organizations, there is a product owner on each development team who was responsible for answering team member questions and for preparing the user stories for the upcoming sprints. Most survey respondents (98%) report having product owners on development teams but, in 32% of the cases, they were part-time employees. In these case studies and in 60% of the survey responses, hierarchical relationships exist between product owners on the development team and a product
manager or “chief product owner.” The latter is the person to whom the product owners on each development team turn for direction and advice. The product owner teams meet regularly to address issues and establish priorities.

In four case studies, there was not a product owner on each team. In three cases, an effective solution was adopted, but in one case no effective solution was found. In two effective cases, a product manager with authority and interest filled the role. In the other effective case, there was a very high level of commitment from the customer organization and very good collaboration between the customer organization and the project organization to the point that they referred to themselves as a team. In the ineffective case, the product owner had insufficient knowledge, availability, and decision-making authority. In this case, the implementation of agile was unsuccessful.

The Role of Analysts

The roles of functional and system analysts are rare in descriptions of agile methods in the literature (Hoda, Noble, & Marshall, 2013; Omar, Syed-Abdullah, & Yasin, 2011). Two of the case study organizations took radically different approaches to the roles of analysts. In one organization the roles have been eliminated. Another organization has an analyst on each development team. The other case study organizations have analysts in the project organization, but not on the development teams. The survey responses indicate that 30% of development teams have functional analysts as team members. In cases in which the ScrumMaster was previously a system analyst, he or she is able to bring this expertise to bear on the project. The question of the roles of analysts remain largely unresolved.

The Role of Architects

All of the case study organizations had architects in the project organization, but not on the development teams. In most cases, an architecture team was part of the project organization. The survey respondents indicated that 53% of their development teams have architects as members, at least part-time, and that 50% of their project organizations have architecture teams. The projects with both an architecture team and architects on their development teams tend to have architects on the teams on a part-time basis. Architects on the development teams are also members of the architecture teams where these exist. In the case study organizations, functional analysts on development teams are also members of a team led by a system architect. The roles of architects and system analysts begs the question: How is the system architecture developed on large agile projects? This is the subject of the next section.

The Impact of Agile Implementation on Project Initiation

Sprint Zero

The expression “sprint zero” is often used to identify the early activities of an agile project before coding begins. During the interviews, several respondents used the term, but the activities to which they referred varied considerably from one person to another even in the same organization. Seventy-three percent of the survey respondents reported using the term. Table 4 summarizes the list of activities that interviewees included in the expression iteration zero, followed by the percentage of survey respondents who include these activities in the sprint zero. This pattern is very similar to that observed in the case studies.

All of these activities would need to be done early in the project, but most respondents explicitly exclude some of them from what they consider to be the sprint zero. There is obviously a semantics problem, as the respondents who use the expression “sprint zero” do not agree on its meaning. All of the case study projects and 89% of the survey respondents reported devoting time to these activities prior to the beginning of development per se. An examination of the projects that did not devote time to these activities prior to the beginning of development per se revealed that they were smaller projects and projects considered to be emergencies. Although there is a clear pattern for the majority of projects, there is considerable variation.

System Architecture and Front End Planning

One of the agile principles (Agile Alliance, 2001) is: “The best architectures, requirements, and designs emerge from self-organizing teams.” However, activities related to system architecture before the beginning of software development per se were observed in all the case studies and in all of the survey responses, except for three, which stands in stark contrast to the agile principle of emergent architecture. All interviewees reported that the time and effort invested in architecture and front end planning prior to the beginning of development were significantly less than those with traditional methods. On average, survey respondents reported devoting half the time employed with traditional methods. However, there was considerable variability in responses, with some survey respondents reporting no difference, whereas others reported very significant differences. The fact that some survey respondents reported no difference is intriguing and deserves further investigation.

Interviewees were asked what proportion of the sprints was planned before development began and the responses varied a great deal. In one
case study organization all of the sprints were planned in details up front. It should be noted that this case study organization had a strong culture, which required that projects be well defined prior to approval. In other organizations, only a very small number of sprints were planned in advance. The survey respondents report that, on average, 34% of sprints were planned up front, but showed the same variability, with responses ranging from 0% to 100%. This may be an indication that, in some contexts the management of projects has much in common with traditional methods that plan the entire project in detail before starting execution in a plan-driven approach. The survey respondents report that, on average, 57% of the features actually delivered were in the product backlog at the outset. There is again considerable variation among the responses.

The scope is defined in detail in user stories, which are typically not produced far in advance. All the case study organizations and 79% of survey respondents report that user stories are prepared three sprints in advance or less. The most common pattern is therefore to produce a summary architecture, to plan one third of sprints, and to define more than half of the product backlog prior to beginning development per se and to produce user stories one to three sprints in advance during project execution. There is, however, a great deal of variation.

**Integration with Other Systems**

A prominent feature of the case study interviews was the frequent mention of issues related to the integration of the system being developed or modified with many other systems within the organization and with systems external to the organization. Likewise, survey respondents report that their projects are integrated with an average of ten other systems. Interviewees report that the integration with other systems prevented the frequent deliveries of software features to users because of the integration and testing required and because of organizational policies that limited releases to a few times a year, violating the agile principle of frequent releases (Agile Alliance, 2001). Fifty percent of survey respondents report that organizational or technical constraints delayed the deployment of functionalities ready for use. There was, however, a great deal of variation in the duration of delays; 11% of respondents reported delays in excess of one year, whereas the remaining report an average delay of 3.6 weeks.

The project teams in the case study organizations are organized to deal with the integration issue. The primary strategy is to have human resources available to the team that are experts in the integration with the other systems. This reduces the impact of testing and integration with other systems somewhat but, despite these measures, the delays in delivery remain significant. In several of the interviews, the impact of the organization’s technology was brought up as an explanation for the impossibility to remove this barrier to the frequent releases. Two of the case study organizations are changing their database structures to make the systems less interdependent and to allow more frequent releases; this, however, is a very expensive and long-term goal.

**Agile Project Organizations**

**Project Organizations**

All the case study projects have rather large project structures. The case study projects have four development teams, on average, whereas the projects described in the survey are larger—with an average of nine development teams. In addition to the development teams, the project organizations had many other individual members and other committees or teams. On average, 94 people worked on the projects in the survey during the most intensive period (full-time equivalent). As stated earlier, most projects have resources within the project structures and outside these structures to deal with the issue of integration with other systems and most, but not all, projects had project managers. A small proportion of the committees, such as the steering committees and client acceptance committees, have the role of coordinating with the rest of the organization. But the majority of the teams, committees, and individual members play roles in the coordination of the work of the development teams. Specialized personnel on the development teams tend to also be members of the corresponding specialist teams where the coordination within their area of specialization takes place. One of the most common features of the project organizations is the Scrum of Scrums in which the ScrumMasters meet regularly with other participants, including the project manager. Four of the six case study organizations have such teams, and 75% of the projects described in the survey do as well. Although there is great variety in the particular structures set up to manage each project, there is a common pattern of having a large number of teams or committees and individuals in specialist roles, in addition to the development teams.

**Development Team Composition**

The recommended size of development teams is between five and nine members (Dingsøyr et al., 2014; Schwaber, 2004; Schwaber & Sutherland, 2013). However, one of the case study projects and 16% of the projects described in the survey have larger development teams: between 10 and 15 members according to survey results. All of the case study projects have a full-time ScrumMaster on each team, whereas 98% of the development teams described in the survey have ScrumsMasters, some of whom were part-time. All of the case study development teams and 96% of the teams described in the survey have daily stand-up meetings, which is a feature of the Scrum methodology. There is an effort to maintain stable team composition in all the case study projects and in 89% of the organizations described in the survey.
All members of each of the case study development teams are collocated and worked in open space environments, whereas 54% of the teams described in the survey do as well. The teams in five of the six case study organizations are located geographically within one kilometer (approximately one half of a mile) of each other and, in almost all cases, in the same building. The development teams described in the survey are much more dispersed geographically: 60% have members in different time zones, which is consistent with the VersionOne (2016) survey results. The development teams in the case study organizations and in the survey have much in common. The differences can largely be explained by the differences in the data collection methods, between interviews in organizations in the authors’ home city, and an online survey.

Discussion
The results from the case studies and from the survey are very consistent. In most cases, the results are very similar, whereas in a few cases the survey adds details and perspectives to the more limited number of projects and organizations in the case studies. The results are somewhat paradoxical in that some features are common to almost all observations, whereas others show extreme variability. The common elements are:

• Scrum is the dominant methodology and almost all projects have ScrumMasters who have daily stand-up meetings. Agile coaches are used to support ScrumMasters and development teams;
• Implementation strategies almost always start with pilot projects, which are almost always small and simple projects;
• The front ends of the projects are remarkably similar. The activities of the front end include the planning of sprints, the production of a summary architecture, the writing of epics and user stories, and the creation of the product backlog. The time and effort devoted to these activities are significantly less than those with traditional methods;
• Approximately two-thirds of the scope is defined at the outset in the product backlog, but the detail is provided only one or two sprints in advance in user stories; and
• The project organizations are quite large. In addition to the development teams, the project organizations have several other teams, committees, and individuals with specialized expertise who are responsible for the coordination of the work of the development teams and the technical excellence of their respective areas of specialization.

Within this common pattern, there is considerable variability. Some of the most significant areas of variation are:

• Despite a few common features, the implementation strategies vary significantly;
• Despite the similarities found in the front ends of projects, the meaning of the term most commonly used to identify the front end “sprint zero” varies a great deal even within organizations;
• The extent of front-end planning of sprints varies from almost no planning to planning of all the sprints prior to approval and initiation; and
• There is extreme variability in the details of the project organizations.

Both common patterns and the objects of great variability are important results; from a research perspective both identify opportunities for further research. Because this is an exploratory study of a subject that has received little attention in the research literature, additional studies are needed to confirm both common patterns and the objects of variability. Further research should investigate the reasons for both. From a practitioner perspective, it is important to know the choices other organizations have made after some experimentation with agile methods on large projects so as to benefit from their experience.

Returning to our research questions:

• At the project level is: What challenges are encountered when applying agile methods to large multi-team software projects and what practices have been developed to alleviate these challenges?
• At the organizational level is: How does the context of large complex organizations affect the adaptation and adoption of agile methods and vice versa?

Three levels of analysis can be distinguished in the results: the development team, the project, and the interaction between the project and the organization.

The Development Team Level
The investigation of development teams is not the focus of this research, because agile team functioning is addressed abundantly in the literature. For this reason, the literature review did not include this topic; however, interviewees spontaneously provided detailed descriptions of their development teams and several questions related to the topic are included in the survey instrument. The examination of this information has led to the observation that the internal functioning of agile development teams is very similar regardless of the number of development teams in the project. Agile methods are based on self-organized teams in which there is limited specialization among the team members. In a few cases, there was tension between the high level of specialization in the large bureaucratic organizations and the flexibility of agile teams, but this was managed locally within the teams and did not present a major challenge. Agile team functioning is not addressed further here.

The Project Level
The differences between small and large projects are more at the project level. Projects with only one development
team typically have a limited number of other human resources in the project organization outside the development team; these are typically a product owner; technical specialists such as architects, analysts, testers, and documentarists. Single development team projects often do not have a project manager because this role is filled by the ScrumMaster. Larger projects are faced with three organizational challenges: the coordination of multiple development teams, the organization of a greater number of specialists outside the development teams, and the integration with other systems. The three are interrelated.

Larger projects have multiple teams or committees of specialists, including the meeting of ScrumMasters in Scrums of Scrums. When there are product owners on development teams, they typically meet on a product owner team with a more senior product owner or product manager. When specialists are full-time or part-time members of development teams, they typically meet on specialist teams where they deal with both issues related to their area of specialization and the coordination of the development teams as it relates to their specialization. The administrative coordination takes place in the Scrums of Scrums, usually attended by the project manager. Frequent demos, testing, integration, and retrospectives are at the heart of agile methods because they provide additional opportunities for the coordination among development teams and across areas of specialization.

Large projects also create challenges for the project manager role. Most agree that the impact is significant, but it is difficult to see a generalizable pattern in the adjustments taking place. In some situations, project managers devote more effort to the coordination of development teams, but in others less. In a minority of cases, the project manager role has been abolished. Most agree, however, that cases in which the project manager role has been maintained, it has become more strategic and is focused more on stakeholder management. It is too early in the evolution of the management of large agile projects to come to a definite conclusion on this subject.

**Interaction between the Project and the Organization**

Most other challenges are related to the interaction between the projects and the organization. The implementation of agile methods in a large organization with well-established traditional methods is a significant organizational change. As with any significant change, management support is critical (Young & Poon, 2013). The acceptance and support of IT and business unit managers as well as development personnel are also very important. Being knowledgeable of agile methods is a necessary condition for support.

One of the biggest challenges is the relationship between the project and the client organization, which is related to the challenges with the role of product owner. The transition from traditional to agile methods is a radical change. Business unit managers are, on average, less knowledgeable and less supportive of agile methods. Agile methods require them to prioritize their needs much better, be more involved in projects, commit significant resources, and respond more quickly to requests for clarification of business rules and priorities. They also create ambiguity as to the exact nature and scope of the project deliverable. Two elements are keys to the creation of an effective working relationship between the business unit and the project; first, the creation of a partnership between the customer organization and the project based on a clear understanding of each other’s context and needs; and second, the role of product owner. One cannot be effective without the other.

There are conflicts between large traditional organizations and agile principles that are related to structures, processes, and culture (Livari & Livari, 2011). One of the biggest challenges is the difference in role definitions between the two. The strategy organizations have adopted to dealing with all of these problems is to use pilot projects to isolate the problems and to develop new processes and new role definitions. The project approval process in traditional organizations that requires project parameters be well-defined in advance is another significant challenge—this is both a process and a cultural issue. For internal projects, the solution has again been negotiating special arrangements on pilot projects. For projects with contracts with external customers, the issue has yet to be resolved, specifically in relation to scope definition. A change in leadership style, from command and control to styles approaching servant leadership, is again a very significant change organizations are addressing on pilot projects (Greenleaf, 2002). It is too early in the evolution of these changes to know how they will develop in the future.

**Conclusion**

Agile methods are being used more and more on large software projects in large organizations. The use of agile methods in this context requires significant adaptations at both the project and organizational levels. There are fundamental contradictions between large bureaucratic organizations with well-established traditional software development methods and agile principles and practices. The resolution of these contradictions is currently ongoing but is still incomplete. Some aspects of the forms these will take in the future are already quite clear, but others will only become clear as the evolutionary process progresses. This is a subject that will require further research as the adoption and adaptation processes progress.

**Future Research**

Some of the most important outstanding questions are:

- What will the project manager’s role be in the future? Will there be project managers in this type of context?
Will the answers to these questions be contingent upon yet to be unidentified conditions?

- To date, the effect of the use of agile methods has been primarily at the project level, with little or no reconceptualization at the program or portfolio level. However, scaling frameworks that propose solutions at these levels are gaining in popularity. How will agile methods affect program and portfolio management?
  - Projects with internal business units as customers are in a situation quite different from those with external customers under contract:
    - For internal projects, how will the relationship between business units and projects evolve and will this fundamentally change the entire organization?
    - For external projects, how will the use of agile methods for systems development affect the entire organization, with redefinitions of the roles of other departments and the relationships with customers, in what might become “agile end-to-end”?

References


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INTRODUCTION

Conflicts within firms represent an avoidable and persistent issue that demand up to 20% of individual employees’ time (Song, Dyer, & Thieme, 2006). Thus, this study examines the role of team conflict within the innovation and new product development (NPD) context. Firms rely on NPD teams to maintain the ability to innovate and achieve higher levels of NPD success (Liu, Chen, & Tao, 2014). NPD project teams are normally formed with members from different functional departments that integrate different beliefs, viewpoints, and so on (De Luca & Atuahene-Gima, 2007). NPD project team members are seen as sources of diverse sets of knowledge, approaches, abilities, and experience. They are expected to provide fast and flexible answers, offering innovative problem-solving approaches as well as stimulating efficiency and increasing the level of satisfaction among members. However, team conflicts among members can often arise in this context, undermining both information processing and the resulting team performance (Cronin & Weingart, 2007; Somech, Desivilya, & Lidogoster, 2009), and the impact of this on NPD success is underexamined in the literature. Whether team conflict should serve as a mediator or moderator thus remains unclear (Costa, Passos, & Bakker, 2015). Moreover, whether the pattern of the influences of team conflict on NPD success is linear, quadratic, or something else is also subject to further validation.

NPD teams can be seen as open information processing systems that rely on the interdependency of the team members’ relations and the activities in which they engage, and that change dynamically depending on the shifting roles of the team members (De Dreu, Nijstad, & van Knippenberg, 2008; Humphrey & Aime, 2014; Schippers, Edmonson, & West, 2014). By employing a more dynamic conceptualization of teams, this study emphasizes the interactions among team members that occur during teamwork that create changes in the team. Following Gersik (1988, 1989), this study introduces the concept of team reflexivity as a process that enables members to reexamine the team’s current procedures and structures in order to carry out the radical changes that are often needed to cope with the uncertainties of the NPD context. In other words, team dynamism is likely to increase when unforeseen external factors impact the team’s activities, and in this context, greater reflexivity may help the team develop a new equilibrium until another radical change is needed.

Moreover, team member reflexivity has also been shown to be an important way to enhance teamwork (Carter & West, 1998; Konradt, Otte, Schippers, & Steenfatt, 2015; Schippers, Den Hartog, Koopman, & Wienk, 2003) and at the same time to promote NPD success (Hoegl & Parboteeah, 2006; Schippers, West, & Dawson, 2015). According to Marks, Mathieu, and Zaccaro (2001), team reflexivity is understood as a continuous team process that involves
the interactions among team members. Through these interactions, team members perform the reflection that allow them to discuss and monitor the progress of their goals and tasks. In short, team reflexivity can be categorized as a transitional process by which NPD team members are better able to track the accomplishment of the focal project (Jentsch, Barnett, Bowers, & Salas, 1999; Marks et al., 2001).

According to cognitive fit theory (CFT), team members form mental representations of the specific tasks that they need to complete in NPD projects (Vessey, 1991). This mental representation involves the information that is needed to enable team members to work together and solve their current problems (John & Kundisch, 2015). By employing CFT, this study considers that team reflexivity is composed of each team member’s interactions as a way of facilitating the extraction of the information that is needed to achieve the focal tasks. In this way, team reflexivity can reframe the team members’ mental representations, which may then increase understanding of the tasks that need to be undertaken. Because NPD projects always need new information to be obtained and processed, so as to understand the dynamic project environment (Zhu & Watts, 2010), greater team reflexivity can permit members to better integrate and interpret different perspectives, and thus adjust the strategies they are using.

When NPD team members become conscious of the need to carry out a continuous analysis of the activities and processes that have been undertaken in a project, it is more likely that they will also carry out a deep reflection with regard to the emerging challenges that need to be considered in the context of complex NPD projects.

For example, if a team member is not familiar with the required task, and the task is highly complex, then he or she will need to interact with the other team members to obtain a deeper level of understanding. The resulting seeking and integration of ideas may alter the team members’ mental representations, thus improving their understanding of the present situations, processes, tasks, and goals. The reflexive ability of the team members or task force as a whole may thus enable them to better comprehend their current work and create innovative ideas (Wong, Tjosvold, & Su, 2007). Team reflexivity can serve as a tool that enables teams to assess the current environment, and this is important because of rapid changes in consumer preferences. Team reflexivity is needed to decide the best ways to meet the real desires of customers, as well as to determine the appropriate strategies for coping with them (Hammredi, van Riel, & Sasovova, 2011).

Reflexivity is critical to the deeper analysis of new ideas and the choice of the best strategies that can enable team members to meet changing market demands (Ellis, Carette, Anseele, & Lievens, 2014). In other words, reflexivity is seen as the main activity of information processing, as it can enable NPD teams to better comprehend how to work together while developing better products or innovative processes. In the context of the information processing activity of team reflexivity, team conflict could be the result of the different approaches that team members employ to express their thoughts, choices, and ideas to one another, while carrying out their own information processing (Song et al., 2006). Therefore, the need to maintain high reflexivity may also result in high levels of team conflict, although the interaction between these two factors has rarely been discussed in the literature. For example, team conflict can be considered a dynamic phenomenon. Team conflict can affect both how team members assess the focal individual and the development of reflexivity within teams.

The aim of this study is to fill two research gaps in the literature. The first research gap refers to the antecedents of the reflexivity of team members. Many studies have recognized the importance of team reflexivity in NPD success (Schippers et al., 2014, 2015). However, there have been few works examining the effects of existing knowledge, task familiarity, and procedural justice on team reflexivity. The first variable, based on the knowledge-based view (KBV), NPD success depends on the organization’s capability to deal with its existing knowledge and generate new knowledge (Zhou & Li, 2012). Based on organizational learning theory, an organization’s store of existing knowledge may ease the processing of information that is used by NPD teams (Brockman & Morgan, 2006). Lee and Sukoco (2011) found that existing knowledge is important to ensure a high level of team reflexivity, but their study did not examine the influence of existing knowledge on task familiarity, and the possible direct and indirect effects on NPD success were also neglected. This study thus proposes existing knowledge as an important driver of team reflexivity.

In the second variable, Lee (2013) proposed project orientation and task familiarity as possible additional drivers of team reflexivity. Other researchers also demonstrated the positive effects of task familiarity on team performance through improvements in different activities, such as problem solving (Lee, 2013; Littlepage, Robison, & Reddington, 1997) and communication and coordination among team members (Espinosa, Slaughter, Kraut, & Herbsleb, 2007). Harrison, Mohammed, McGrath, Florey, and Vanderstoep (2003) also argued that the influences of task familiarity on team performance may be contingent on the nature of the task in terms of duration, complexity, and the availability of related research (Soderquist & Kostopoulos, 2012).

For the third variable, even though the innovation and NPD literature has proposed that procedural justice may be a relevant factor to enhance the functioning of NPD teams, the findings with regard to procedural justice in an innovation context remain inconclusive. For example, previous studies have
demonstrated the link between procedural justice and innovative behaviors (Ramamoorthy, Flood, Slattery, & Sardessai, 2005; Schepers & van den Berg, 2007), as well as with the collaborative behaviors of NPD groups (Dayan & Di Benedetto, 2008). Moreover, continuous unfair treatment of NPD members by team leaders may reduce their level of creativity (Streichr, Jonas, Maier, Frey, & Spiebberger, 2012). However, Dayan and Basarir (2009) stated that procedural justice does not have any association with team reflexivity. This study thus aims to further validate the effects of procedural justice on team reflexivity.

The second research gap is related to how the contingency effects of reflexivity and team conflict can improve NPD success. Conflict here is the result of the friction among team members, and this is both a real challenge and inherently unavoidable in an NPD context (de Wit, Greer, & Juhn, 2012; Song et al., 2006). Schippers et al. (2015) contended that the need to create innovative new ideas and make decisions related to them will often result in conflict that may waste valuable time and harm relationships among team members. Moreover, when conflicts occur, unstructured processes may arise, leading to further irritation and improper decisions (Edmondson & Smith, 2006). Many scholars have demonstrated the negative relationship between team conflict and NPD performance. However, most previous studies tend to focus on conflict management and its impact on performance (Xie, Song, & Stringfellow, 1998) or on the direct effects of conflicts among team members (de Wit et al., 2012). Because conflict is expected in an NPD context (Lam & Chin, 2005) and its results remain unclear, this study adopts a contingency perspective to determine the team reflexivity–NPD performance relationship in light of team conflict (Costa et al., 2015). This work thus introduces team conflict as a potential variable that can moderate the relationship between team reflexivity and NPD performance.

The remainder of this research is structured as follows. First, a review of the important literature is introduced, and then the conceptual framework and research hypotheses are developed. After this, the corresponding methodology is presented, as well as the empirical results. Finally, the conclusions and managerial implications of this work are discussed. Overall, it is expected that the research gaps noted above can be addressed through the empirical validation carried out in this study.

Hypotheses Development

Operational Definitions of the Research Constructs
Following West (2000) and De Dreu (2002), this study defines team reflexivity as the conscious reflection that team members do related to team functioning, with a focus on the group’s goals, strategies, and procedures, in which team members perceive that they and their coworkers review, discuss, and modify their work to improve effectiveness. On the other hand, Brockman and Morgan (2006) referred to existing knowledge as an organizational memory that should occupy a key role in NPD as a form of acquired knowledge. This study defines existing knowledge as the amount of information that an organization possesses regarding various areas, or the superior information that an organization can possess on a specific theme that can be integrated into organizational learning and memory. In addition, following Adams, Roch, and Ayman (2005), this study defines task familiarity as the amount of knowledge that team members have about their main task, crew, and work-environment settings. Indeed, with regard to accomplishing any NPD task, knowledge (e.g., about the physical environment, work activities, and so forth) is relevant for making teamwork more productive (Tsai, Baugh, Fang, & Lin, 2014). Notably, as team members work together and spend time doing one specific task, it is more likely that they will become more familiar and develop more knowledge about the task itself, as well as one another (Haon, Gotteland, & Fornerino, 2009). In an NPD context, team members will encounter great task uncertainty. Therefore, NPD processes may require a high degree of exploration from the team members, which may be enhanced by the familiarity that members have regarding previous tasks (Tang, Mu, & Thomas, 2015). Moreover, NPD processes may comprise problems and challenges that are new to the team members, thus transforming familiar tasks into unpredictable problems, impacting the ease through which team members understand the development of new ideas or knowledge. However, even if it is to a limited extent, task familiarity will reduce the cognitive overload that is otherwise associated with new processes (Speier, 2006).

Organizational justice theory (OJT) (Greenberg, 1987) suggests that, in the context of NPD teams, procedural justice can be understood as the team members’ perceptions of the justice of the different procedures, regulations, and rewards employed by the R&D manager when making decisions (Akgün, Keskin, & Byrne, 2010; Li, Bingham, & Umphress, 2007). This study defines procedural justice as the NPD team members’ perceptions of the fairness of the R&D managers’ decisions concerning rules and processes related to their work. For example, the R&D manager usually makes decisions such as: (1) determining the NPD project’s goals; (2) leading the commitment toward NPD; (3) distributing resources for the development of NPD projects; and (4) setting the rules related to searching for ideas, product trials, and new product launch activities (Li et al., 2007). Further, the procedures and criteria used by NPD managers for making decisions regarding such projects should ideally be objective, representative, transparent, correctable, and ethical (Lee & Sukoco, 2011).

Following De Dreu and Weingart (2003), this study defines team conflict as the result of the pressures that arise among team members as a result
of real or apparent differences. Team members provide the team with social inputs as well as task inputs, and thus, this study posits that conflict in teams encompasses both relationship and task concerns (Garner & Poole, 2013; Jehn, 1995). Relationship conflict refers to the conflicts that arise because of differences in team members’ personal styles, political preferences, and values or personal tastes; task conflict refers to conflicts related to the dissemination of resources, processes, organizational policies, and the analysis of facts (De Dreu & Weingart, 2003; Garner & Poole, 2013). Finally, this study defines NPD success as the extent to which the new product has accomplished its expected performance (Akgün, Keskin, Lynn, & Dogan, 2012).

**Relationships Among Existing Knowledge, Team Reflexivity, and Task Familiarity**

Following the knowledge management perspective (Argyris & Schön, 1978 Basadur & Gelade, 2006), this study proposes team reflexivity as a possible mechanism that may integrate the existing knowledge of different team members. Organizations need to implement rigorous knowledge management practices to ensure the transformation of tacit knowledge into more explicit knowledge. Tacit knowledge is understood as the knowledge that is inside the heads of team members, while explicit knowledge is the knowledge that can be stored externally in various information systems (Basadur & Gelade, 2006).

For example, Cohen and Levinthal (1990) asserted that existing knowledge may be an enabler of better problem setting, evaluation, and solution generation, and the starting point for taking new opportunities (Tang & Murphy, 2012). The amount of knowledge that an organization possesses may be useful for identifying the value of new information (West, 2000). High levels of existing knowledge will enrich team reflexivity, as well as the debates, interactions, and communications that occur among team members (Lee, 2008). This study argues that how an organization employs its existing knowledge may determine the strengths and weaknesses of its NPD projects and teams (Li, Lee, Li, & Liu, 2010). However, the simple availability of existing knowledge is not sufficient to ensure the successful development of new products. In order to achieve this, NPD projects need to develop a shared thinking process to employ knowledge in a more innovative form. Therefore, this study considers team reflexivity as a knowledge management practice through which organizations can enhance the use of the knowledge that already exists in the minds of the NPD team members (Eisenhardt & Santos, 2002). Team reflexivity is also a learning process that accomplishes both the monitoring of current methods and the generation of new knowledge (Argyris & Schön, 1978). Moreover, organizations need to consider the possibility that team members may feel that they are at risk of losing personal advantages and power when they interact with one another and share their knowledge (Tchoun & Chatzoglou, 2008). This may lead team members to hoard the knowledge they hold, and thus diminish the benefits that NPD projects may obtain from reflection.

In an NPD context, it is important for information to be processed appropriately within the related teams in order to achieve new product success (Akgün, Keskin, Lynn, & Dogan, 2012). An organization’s existing knowledge base may influence its adaptation capabilities (Marsh & Stock, 2006), which in turn may affect team reflexivity. Because reflexivity may foster the deeper discussions needed to search for new processes and develop new products, it is vital to achieve greater team reflexivity. Reflexivity can also help integrate and exploit multiple and redundant forms of knowledge, improving it and producing better processes, with innovative ideas that may be transformed into products that can meet the needs of consumers, thus gaining market share (Farnese & Livi, 2015).

Moreover, to accomplish a higher level of team reflexivity, team members should work to prepare detailed plans, foresee possible problems, and drop obsolete processes in order to employ those that better meet the demands of a dynamic market. This study argues that, based on cognitive fit theory, team members may have a wide existing knowledge base that they need to discuss for further reflection (Lee, 2008). In other words, team members are capable of converting the vast knowledge bases they hold into more productive knowledge through the use of cognitive activities that boost team reflexivity (Marks et al., 2001). In short, because existing knowledge may enhance team reflexivity, this study proposes the following hypothesis:

**Hypothesis H1:** NPD teams that have higher levels of existing knowledge tend to have higher levels of team reflexivity.

In terms of the relationship between existing knowledge and task familiarity, cognitive fit theory proposes that cognition involves a huge amount of mental processing, in terms of activities such as problem solving, reasoning, decision making, and calculating (Tsai, Chou, Liu, & Lin, 2013; Vessey, 1991).

Cognitive fit theory emphasizes that team members may need a large range of existing knowledge in order to develop task familiarity in a complex context like NPD (Speier, 2006). For example, the amount of knowledge needed to solve a problem or to create a unique product concept is more demanding in the context of NPD projects than in many other areas. NPD team members may thus need to hold more existing knowledge in their minds and exercise higher levels of cognitive thinking to be more productive (Goodman & Leyden, 1991; Li et al., 2007), which can then increase the level of task familiarity. This study proposes that existing knowledge enhances task familiarity, as stated in the following hypothesis:

**Hypothesis H2:** NPD teams that have higher levels of existing knowledge tend to have higher levels of task familiarity.
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**Relationship Between Task Familiarity and Team Reflexivity**

In terms of the relationship between task familiarity and team reflexivity, Simon (1996) proposed that team members who perform an independent task are more likely to face several difficulties. Moreover, in innovative environments, task familiarity can help the whole team cope with the related complexities, enhancing the level of reflexivity. Through task familiarity, team members may help their partners deal with dynamic tasks and therefore implement appropriate changes to their practices. Task familiarity can also allow team members to share their experiences, which provides an effective system that enables the team to reflect on and respond to a changing environment and do their tasks more successfully (Espinosa et al., 2007; Weick & Roberts, 1993). Based on the development of task familiarity, teams may develop a shared mental model that allows members to better organize key knowledge and enhance their reflexivity (Espinosa et al., 2007). Therefore, this study proposes the following hypothesis:

**Hypothesis H3:** NPD teams that have higher levels of task familiarity tend to have higher levels of team reflexivity.

**Relationships Among Procedural Justice, Task Familiarity, and Team Reflexivity**

Fair treatment of NPD team members is extremely important for the development of their desirable behaviors and their related outcomes (Blader & Tyler, 2009; Georgalis, Samaratunge, Kimberley, & Lu, 2014). With higher levels of perceived procedural justice, team members may show more respect to one another. This will then create more cohesiveness in the process of task-related information analysis (Dayan & Basarir, 2009). Team members who perceive higher levels of procedural justice are more willing to collaborate with one another, identify possible problems, and engage in activities to achieve better outcomes. Procedural justice can therefore improve knowledge sharing and interaction among team members, which may enhance task familiarity in the NPD team.

This study also employs exchange theory to explain the influence of procedural justice on team reflexivity (Emerson, 1976; Lee & Sukoco, 2011). Higher levels of procedural justice can result in higher levels of trust toward the company (Lee & Sukoco, 2011), as well as enhance NPD (Dayan & Basarir, 2009). Team members who perceive equal treatment in various activities are more willing to connect and debate with one another when participating in the decision-making process, thus helping to create or find appropriate solutions (Akgün et al., 2010), which is much less likely when team members do not perceive good procedural justice (Lavelle, Rupp, & Brockner, 2007; van Dijke, De Cremer, Mayer, & van Quaquebeke, 2012). As a result, procedural justice stimulates NPD team harmony and enables team members to look beyond their own benefits, while also enhancing team reflexivity (Colquitt, LePine, Piccolo, Zapata, & Rich, 2012; Naumann & Bennet, 2002). It is thus expected that procedural justice will enhance team reflexivity, as stated in the following hypotheses:

**Hypothesis H4:** NPD teams that have higher levels of procedural justice tend to have higher levels of task familiarity.

**Hypothesis H5:** NPD teams that have higher levels of procedural justice tend to have higher levels of team reflexivity.

**Relationship Between Team Reflexivity and NPD**

Based on organizational learning theory (Lipsmitz, Popper, & Oz, 1996; Templeton, Lewis, & Snyder, 2002), this study proposes that NPD teams can be seen as information-processing systems (De Brentani & Reid, 2012; De Dreu et al., 2008) composed of several activities, such as dissemination, examining, laying up, and employing various forms of information. Team members have different cognitions, so the team as a whole is exposed to some information-processing flaws (Schippers et al., 2014), which may damage the NPD process. Moreover, team information processing may result in a number of team outputs, such as decisions, planning, product-related projects, or the provision of services (Akgün et al., 2012; Schippers et al., 2014). Following this rationale, team reflexivity may help NPD teams identify and monitor the best practices and rule out routines that are ineffective as a result of environmental complexity (Farnese & Livi, 2015; Marks et al., 2001). A process of continuous reflection within NPD teams may enhance the gathering and dissemination of information, which are key activities for NPD success (Schippers et al., 2014).

According to reflexivity theory (West, 2000), through reflexivity, NPD teams should be capable of understanding and interpreting the actual environmental circumstances and, at the same time, internalizing the objectives they have been given (Schippers, Homan, & Knippenberg, 2013). Tjosvold, Tang, and West (2004) proved that reflexivity is related to the development of high degrees of innovation. Therefore, NPD teams that are committed and have high levels of reflexivity tend to be more focused on the complex environment within which they are operating and any technological turbulence that it contains (Hoegl & Parboteeah, 2006). As a result, reflexivity enables NPD team members to discuss and propose possible solutions for the development of creative or unique products (Farnese & Livi, 2015). Additionally, reflexive NPD teams are expected to better use the team members’ know-how to achieve NPD success (Schippers et al., 2014; Tjosvold et al., 2004). It is notable that, on the whole, when team members keep track of a reflexive process, the possibilities of expressing some opinions that do not correspond to the search for the best solutions or the creation of ideas are minimized. In this context, views that express extreme disapproval of other
team members are less likely to arise, thus enhancing the information sharing that is needed to achieve higher levels of NPD success (Hülsheger, Anderson, & Salgado, 2009). This study proposes the following hypothesis:

**Hypothesis H6:** NPD teams that have higher levels of team reflexivity tend to have higher levels of NPD success.

**Mediating Effect of Team Reflexivity**

Because of the extreme importance of reflexivity for NPD teams in achieving higher levels of NPD performance, this study suggests that team reflexivity should have a mediating effect on the influences of existing knowledge, task familiarity, and procedural justice on NPD performance. Team reflexivity benefits from a greater stock of existing knowledge (Lee, 2008), as this can enable team members to reflect and interact with one another (Farnese & Livi, 2015). Moreover, task familiarity enables team members to recognize a shared cognition in terms of expertise and knowledge about the focal tasks, so they can reflect effectively based on mutual understanding (Espinosa et al., 2007). Team reflexivity also benefits from better procedural justice by improving the creation of an appropriate work environment through the positive perceptions that team members have regarding the fairness of top management (Dayan & Basarir, 2009; Li et al., 2007). Overall, NPD success will improve as a result of the effects of existing knowledge, task familiarity, and procedural justice, as mediated through the beneficial impact of team reflexivity. This study proposes the following hypothesis:

**Hypothesis H7:** Team reflexivity mediates the relationships among existing knowledge, task familiarity, and procedural justice, and the effects of these on NPD success.

**Moderating Effects of Team Conflict**

This study adopts the concept of self-verification theory, which claims that team members who face conflicts are incapable of being objective in their decision making when their abilities and capabilities are continually being challenged (Swann, Polzer, Seyle, & Ko, 2004). Self-verification theory is founded on the premise that team members want the rest of the team to see them the way they see themselves (Swann, Pelham, & Chideester, 1988). The existence of conflict among team members may lead to difficulties in this regard, which will further decrease team members’ perceptions of the psychological rationale for their situation by decreasing the perceptions of themselves, while at the same time decreasing their support for the current reality. In a team with positive self-verifying evaluations, members are more likely to perceive that their interactions develop smoothly. This then promotes a commitment to further teamwork (Solansky, Singh, & Huang, 2014). Moreover, relationship conflict may weaken the influence of team reflexivity on NPD success because it decreases the level of cooperation among team members (Jehn, Greer, Levine, & Szulanski, 2008), caused by the lack of self-verification. It is also suggested that under a high level of relationship conflict, NPD team members will feel frustrated and dissatisfied. On the one hand, relationship conflict may not allow team members to feel part of the team in a self-verifying process, and members may perceive that it is not safe to behave in certain ways, which will weaken the relationship between team reflexivity and NPD success (Swann et al., 2004). On the other hand, task conflict can be understood as a catalyst that stimulates team members’ thoughts and problem-solving skills. Team members with high levels of reflexivity are better able to face a challenging market, are more willing to accept reflections based on different perspectives, and are more likely to transform their differences in perspectives into the development of better new products. Therefore, the positive consequences of task conflict regarding thought processing and problem-solving skills are more likely to occur within reflexive teams (Costa et al., 2015).

Based on the above discussion, it can be expected that team conflict will result in team members spending too much time following their own preferences; thus, they will lose sight of the main directions of their assigned tasks (De Dreu & Weingart, 2003). The positive effects of team reflexivity on NPD success will be weakened when there are more relationship- and task-based conflicts, as stated in the following hypotheses:

**Hypothesis H8a:** The positive influence of team reflexivity on NPD success will be weakened when an NPD team has higher levels of relationship conflict.

**Hypothesis H8b:** The positive influence of team reflexivity on NPD success will be strengthened when an NPD team has higher levels of task conflict.

Based on the hypotheses set out above, a research model is proposed for further empirical validation, as shown in Figure 1.

**Method**

**Research Setting and Data Collection**

In order to test the suggested framework and hypotheses, this study collected survey data from 254 NPD project team members from 70 high-tech firms in Taiwan. As in Chiocchio (2015), this study defines an NPD project team as a group of people working together who hold different types of knowledge and expertise. An NPD project team lasts for the life span of the focal project, and works with vast amounts of information with the aim of generating new ideas and products. We first made telephone calls to the human resources managers of all the high-tech companies in three science parks in Taiwan to ask if they would be willing to participate in our study, and, if so, to identify the most typical NPD team to take part in this project. The human resources managers
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who agreed to take part in this work were then assigned as the contact person for our study. They then introduced the NPD team leaders and NPD team members to the researchers. By choosing these managers as key informants, this study attempted to receive the most objective information regarding the members of the NPD projects. As part of this recruitment process, the confidentiality of the target participants was promised, in order to avoid the issue of coercion with regard to their responses. We next sent an envelope containing five copies of the surveys and asked the members of NPD teams to complete them. Because of the complexity of the data collection process, and to encourage more responses, this study offered a “lucky draw” prize for four of the respondents, which was a coupon to stay for two nights at a five-star hotel in Taipei. Eventually, a total of 254 questionnaires from team members and 70 questionnaires from team leaders were obtained. Moreover, two to four team members in each company answered our questions. Following Gibson, Conger, and Cooper (2001), this study considered that team conflict perceptions among members are completely different from the perceptions of team conflict between members and leaders. Team members’ self-perceptions are composed of their thoughts and experiences, which are stored in their memories, whereas team leaders’ self-perceptions are composed of beliefs related to the team members’ participation in decision making. We thus excluded the 70 responses from team leaders from our further analysis. The firms were located in Taichung Science Park, Hsinchu Science Park, and Tainan Science Park in Taiwan. The majority of the responses came from people working in the mechanical, semiconductor, and IT and electrical industries. Approximately 70% of the firms had been operating for over 16 years, with most having recorded sales volumes of over US$250 million (79.7%). The firm size data indicated that more than 30% of the firms had more than 500 employees. The average age of the team members was 29.7 years (SD = 6.43), 70.5% of them were male, and 85.1% had a college degree or above. The average team tenure was 24.8 months (SD = 3.46). Additionally, most of the team members who participated in this research had more than six years’ tenure, although 80% of the companies had team members with less than 10 years of experience.

Measures

The constructs used in this study were developed based on well-established multi-item scales drawn from the literature, as well as examined by experts. This research used standard procedures to carry out the hypotheses testing, statistical analyses, and refinement (Straub, 1989). All constructs were examined with items that were answered using a seven-point Likert scale (ranging from 1 = strongly disagree, to 7 = strongly agree).

Team Reflexivity: Team reflexivity was measured by three items (α = 0.827) adopted from Hoegl and Parboteeah (2006) that examined the degree to which team members have the ability to be reflexive. These items were: (1) “My team investigated and observed the context and the progress of our
project (e.g., task performance strategies, goals, project requirements, the organizational context, etc.)” (p. 125); (2) “The team adjusted its task performance strategies in response to changes in the context and progress of the project” (p. 125); and (3) “The strategies and work approaches selected were later checked for their appropriateness by the team” (p. 125).

Existing Knowledge: Existing knowledge was measured by three items (α = 0.943) that assessed the degree of current knowledge in relation to the focal NPD project (Brockman & Morgan, 2006; Moorman & Miner, 1997): (1) “A great deal of knowledge about this product category” (p. 305); (2) “A great deal of information about this product category” (p. 305); and (3) “A strong understanding of this product category” (p. 305).

Task Familiarity: Task familiarity was measured by three items (α = 0.899) that examined the extent of knowledge about a task domain that a team member possesses (Brockman & Morgan, 2006; Moorman & Miner, 1997): (1) “A great deal of knowledge about this product category” (p. 102); (2) “A great deal of information about this product category” (p. 102); and (3) “A strong understanding of this product category” (p. 102).

Procedural Justice: Procedural justice was measured by three items (α = 0.937) to assess the level of fairness that team members perceived (Li et al., 2007): (1) “Our R&D manager adopts decision-making procedures that are fair over time” (p. 213); (2) “Our R&D manager provides a full explanation for final decisions made” (p. 213); and (3) “Our R&D manager respects the project members’ individual autonomy” (p. 213).

Team Conflict: Team conflict was operationalized by task conflict and relationship conflict (Jehn & Mannix, 2001). Relationship conflict was measured by the following items: (1) “Within our NPD team, there are many personal issues which may cause some fights” (p. 243); and (2) “We disagree about non-work issues (e.g., related to social issues or personalities)” (p. 243) (α = 0.889). On the other hand, task conflict was measured by: (1) “We fight about work matters”; and (2) “Our NPD team experiments with a high level of conflict of ideas” (p. 243) (α = 0.957).

New Product Success: New product success was measured by three items considering the product performance (α = 0.934) (Akgün, Lynn, & Yılmaz, 2006): (1) “Overall, the NPD performance exceeds sales expectations” (p. 222); (2) “The NPD performance meets or exceeds sales expectations in dollar terms” (p. 222); and (3) “The NPD performance exceeds the schedule with regard to being produced and commercialized” (p. 222). These items are summarized in Table 1, along with their factor loadings.

Controlling for Potential Common Method Bias
Because this study collected the data from a particular source, there is a possibility that common method bias exists.
within it. This study thus assessed common method bias following the guidelines in Podsakoff, Mackenzie, Lee, and Podsakoff (2003). First, it adopted a rigorous approach to develop the measurements to ensure their clarity. Second, this study applied the Harmon one-factor technique to measure the common variance. The unrotated explained variance of the first factor was 31.58% using the unrotated solution, which is less than 50%. Third, this study also implemented confirmatory factor analysis (CFA) to ensure that all factor loadings were greater than 0.60. The results show that all factor loadings were higher than 0.794, which further confirmed the dimensionality of the constructs. There was thus no need to drop any items in any of the research constructs. All the measurement items were identified as factors for a common latent factor, with the objective of testing the influences of a common method.

**Evaluation of the Measurement Model**

In order to examine the measurement model, this study assessed the construct validity and reliability, and a number of different analytical techniques were employed to achieve this. First, convergent validity was measured by computing the average variance extracted (AVE). All of the values surpassed the threshold of 0.50 (see Table 2), thus demonstrating good convergent validity (Hair, Ringle, & Sarstedt, 2011). Second, discriminant validity was examined by assessing whether the squared roots of the AVEs were higher than the correlations among the other constructs in the research model, with the results shown in Table 2. In addition, to assess the issue of multicollinearity, we computed the inner variance inflation factor (VIF) for reflective constructs. Based on the results, the VIF values were lower than the threshold value of 5 (Hair, Black, Babin, Anderson, & Tatham, 2006). Moreover, we also tested the heterotrait-monotrait (HTMT) ratio (Henseler, Ringle, & Sarstedt, 2015) that obtains an average of the correlations between constructs. The HTMT values were below the cutoff criteria of 0.9. We thus concluded that multicollinearity is not an issue in the present study.

Finally, reliability was measured by carefully examining the composite reliability (CR), and all CR magnitudes for their respective constructs range from 0.898 to 0.979, indicating suitable levels of reliability. These results confirmed that the constructs are appropriate for use in the hypotheses testing.

**Analytical Procedure**

This study conducted data analysis by implementing partial least squares-structural equation model (PLS-SEM). After comparing it with several other techniques, such as variance-based SEM we chose PLS for two main reasons. First, our model aims to carry out a causal-predictive exploration, and some complex relationships are expected among the variables (Chin, 1998). Second, PLS is more suitable when the proposed model has not been tested widely, as is the case in the current work (Teo, Wei, & Benbasat, 2003). On the other hand, this study also used the PROCESS Macro from SPSS in order to carry out conditional process analysis, as developed by Preacher and Hayes (2008). In essence, this approach employs an ordinary least squares-based analysis for testing both direct and indirect effects (Hayes, 2013).
chose PROCESS for the following reasons: First, it integrates many of the most functional procedures, such as SOBEL’s test, RSQUARE, MODPROBE, MBESS, and MODMED (Hayes, 2013). Second, PROCESS allows researchers to build up models that combine examinations of both direct and indirect mediation effects. In this work, PROCESS was implemented to evaluate the mediation role of team reflexivity.

**Evaluation of the Structural Model**

This study examined the hypotheses using SmartPLS 3 (Ringle, Wende, & Becker, 2014). It is important to note that the PLS model is measured based on the goodness-of-fit (GoF) of the model (Vinzi, Trinchera, & Amato, 2010) and $R^2$, which evaluates its predictive power (Chin, 1998). As shown in Figure 2, this study achieved a GoF value of 0.549, which surpasses the cutoff value of 0.36 for large effect sizes of $R^2$ (Cohen, 1988). This shows that the research model had a better estimation power compared with the baseline values (the GoF criteria). Additionally, the research findings supported the predictive power of the model, because the $R^2$ values all exceeded 0.3 (Hermann, Gassmann, & Eisert, 2007). Moreover, this study also computed the Stone-Gaissers test criteria ($Q^2$) to examine the model’s predictive power (DeLeon & Chatterjee, 2015) by using the blindfolding procedure. The results demonstrated that for each endogenous construct, the Stone-Gaissers criteria surpassed the critical value of 0, ranging from 0.407 to 0.546. Finally, this study computed the standardized root mean square residual (SRMR), which is an important model-fit criterion provided for PLS path modeling (Henseler et al., 2015). The results proved the appropriate fit of the model, with an SRMR value of 0.029.

As specified by the path loadings, the direct effect of existing knowledge on team reflexivity shows a significant and positive effect ($\beta = 0.263, p < 0.001$).
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<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Path</th>
<th>Standardized Estimate</th>
<th>t-value</th>
<th>R²</th>
<th>Q²</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₁</td>
<td>Existing Knowledge → Team Reflexivity</td>
<td>0.263</td>
<td>3.161***</td>
<td>0.662</td>
<td>0.546</td>
</tr>
<tr>
<td>H₂</td>
<td>Existing Knowledge → Task Familiarity</td>
<td>0.543</td>
<td>7.097***</td>
<td>0.652</td>
<td>0.480</td>
</tr>
<tr>
<td>H₃</td>
<td>Task Familiarity → Team Reflexivity</td>
<td>0.204</td>
<td>2.674***</td>
<td>0.494</td>
<td>0.420</td>
</tr>
<tr>
<td>H₄</td>
<td>Procedural Justice → Task Familiarity</td>
<td>0.336</td>
<td>4.114***</td>
<td>0.676</td>
<td>0.543</td>
</tr>
<tr>
<td>H₅</td>
<td>Procedural Justice → Team Reflexivity</td>
<td>0.423</td>
<td>5.646***</td>
<td>0.713***</td>
<td></td>
</tr>
<tr>
<td>H₆</td>
<td>Team Reflexivity → NPD Success</td>
<td>0.249</td>
<td>3.156***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₇</td>
<td>TR* Relationship Conflict → NPD Success</td>
<td>−0.116</td>
<td>2.362***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₈</td>
<td>TR* Task Conflict → NPD Success</td>
<td>−0.073</td>
<td>n.s.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Constructs**
- Task Familiarity
- Team Reflexivity
- NPD Success

Note: N = 254 team members; R², coefficient of determination; Q², Stone-Geisser test criteria
n.s. = nonsignificant
***p < 0.01; **p < 0.05; *p < 0.10

Table 3: Evaluation of structural model and hypotheses testing.

This result with regard to Hypothesis H1 is in line with the findings in Lee (2008), which showed that existing knowledge and entrepreneurial proclivity tend to foster team reflexivity and product innovativeness.

The results show that task familiarity has a significant and positive effect on team reflexivity ($β = 0.204, p < 0.001$), and Hypothesis H3 is therefore supported. This result is in line with previous scholars who pointed out that team members who have deep knowledge of their tasks will engage in more reflexivity, thus enhancing the learning process and improving their problem-solving capability (Espinosa et al., 2007; Lee, 2013). Procedural justice significantly and positively predicts team reflexivity ($β = 0.336, p < 0.001$); thus, Hypothesis H5 is supported. Although Dayan and Basarir (2009) did not find any influence of procedural justice on team reflexivity, the result of the current study may be the result of the fact that it was performed within the context of high-tech Taiwanese firms. It is not surprising that in collectivistic, high-power distance cultures, like Taiwan’s, the perceptions of team members with regard to the fairness of the procedures employed by top managers play an important role in fostering team reflexivity. The positive perceptions of team members toward top management’s fairness may create an environment where team members can reflect and interact with one another in order to develop new plans or reconfigure obsolete procedures in ways that enable the results to go beyond those of competitors. Table 3 shows the results in this regard, which highlight the importance of these three factors as drivers of team reflexivity.

The path from existing knowledge to task familiarity is also highly significant ($β = 0.543, p < 0.001$), indicating the importance of the former with regard to enhancing the latter, and thus Hypothesis H2 is supported. This result was also found in Adenfelt and Lagerström (2006) and Li et al. (2010), who explained that existing knowledge may be exploited in order to be useful for the development of new products. Consequently, task familiarity is a process that helps team members be more familiar with their tasks, which is highly important in an NPD context where tasks are continually changing. The results of our analysis also show that the path from procedural justice ($β = 0.336, p < 0.05$) to task familiarity is statistically significant and positive, supporting Hypothesis H4. Finally, the path from team reflexivity ($β = 0.249, p < 0.001$) to NPD success was also positive and significant, in accordance with our predictions, and so Hypothesis H6 is supported. This result is in line with Dayan and Basarir (2009), Lee (2008), and MacCurtain, Flood, Ramamoorthy, West, and Dawson (2010). Overall, the results show that the proposed model has a suitable fit with the collected data.

**Moderating Effect of Team Conflict**

Hypothesis H8a proposes that relationship conflict has a negative moderating effect on the association between team reflexivity and NPD success, as presented in Figure 2, and this hypothesis is supported ($β = −0.116, p < 0.001$). Relationship conflict negatively impacts the influence of team reflexivity on NPD success. In other words, given that team reflexivity can result in higher NPD success, a higher level of relationship conflict can significantly reduce this influence. This result is partially supported by Carnevale and Probst (1998), which suggested that individuals may be more creative when they have a low level...
of conflict. Similarly, Costa et al. (2015) found a negative moderating effect of relationship conflict that reduced the reflection, creative thinking, and problem solving of team members. Furthermore, Hypothesis H8b suggests that task conflict has a positive moderating effect on the association between team reflexivity and NPD success, and this hypothesis is not supported ($\beta = -0.073, p > 0.05$).

**Mediation Effects of Team Reflexivity**

Following Hayes (2013), three models were built for testing the mediation role of team reflexivity. Model 1 contained existing knowledge as the independent variable ($X_1$), model 2 included task familiarity as the other independent variable ($X_2$), and model 3 used procedural justice as the last independent variable ($X_3$). With regard to the statistical inferences, this study employed the percentile bootstrap confidence interval (CI), with 5,000 bootstrap samples required in PROCESS (Hayes, 2013). Following the PROCESS Macro’s guidelines, this research employed “Model 4” from the templates provided by Hayes (2013). Moreover, three mediation models were developed based on the following two equations:

$M = i_1 + aX_{1:2:3} + e_M$

$Y = i_2 + c'X_{1:2:3} + BM + e_Y$

Where $i_1$ and $i_2$ represent the intercepts of the regression lines, $e_M$ and $e_Y$ denote the error terms in the assessment of $M$ and $Y$, and $a$, $b$, and $c'$ represent the beta coefficients for each independent variable in the template called “Model 4” proposed by Hayes (2013), as depicted in Figure 3a and Figure 3b. In this research, $X_1$ is existing knowledge, $X_2$ is task familiarity, $X_3$ is procedural justice, $M$ is team reflexivity, and $Y$ is NPD success.

Based on the results, for the first mediation model, the total direct effect from existing knowledge ($X_1$) on NPD success ($Y$) was significant ($R^2 = 0.344$, $df = 1, 252, F = 64.110, p < 0.001$, path $c$). In addition, the direct effect with team reflexivity as a mediator ($R^2 = 0.421$, $df = 2, 251, F = 45.113, p < 0.001$) is also significant. Even though the path from existing knowledge to NPD success was found to be significant, there was a significant indirect effect of existing knowledge on NPD success through team reflexivity, as indicated by the percentile bootstrapped confidence interval of the indirect effect, $b = 0.296, SE = 0.054, 95\% CI [0.186, 0.401]$. With the same objective, this study also applied the normal theoretical approach, which is analogous to the traditional Sobel’s test (Sobel, 1982), to examine the significance of the mediating effects among the other variables (Hayes, 2013). The mediation effect is significant when its $z$ statistic value is greater than the threshold of the $t$-value = 1.96. The results demonstrate that the $z$-test value for the relationships of existing knowledge $\rightarrow$ team reflexivity $\rightarrow$ new product performance success was 4.872 ($p < 0.001$), and thus over the critical $t$-value of 1.96. According to Hayes (2013), team reflexivity thus serves as a mediator that mediates the influence of existing knowledge on NPD success.

Similarly, in the second model, the direct effect of task familiarity ($X_2$) on NPD success ($Y$) is also significant ($R^2 = 0.338$, $df = 1, 252, F = 65.153, p < 0.001$, path $c$'). In addition, the direct effect with team reflexivity as a mediator ($R^2 = 0.421$, $df = 2, 251, F = 45.171, p < 0.001$) is also significant. Although the path from task familiarity to NPD success is be significant, there is a significant indirect effect of task familiarity on NPD success through team reflexivity, which was computed by the percentile bootstrapped confidence interval of the indirect effect $b = 0.409, SE = 0.076, 95\% CI [0.265, 0.566]$. In the same way, the normal theoretical approach provided a $z$-test value for the relationships of task familiarity $\rightarrow$ team reflexivity $\rightarrow$ new product performance success of 5.314 ($p < 0.001$). Thus, following Hayes (2013), team reflexivity also mediates the influence of task familiarity on NPD success.

Finally, following the same procedure, in Model 3, the direct effect of procedural justice ($X_3$) on NPD success ($Y$) is statistically significant ($R^2 = 0.399$, $df = 1, 252, F = 84.522, p < 0.001$; path $c'$). Additionally, the direct effect that includes team reflexivity as a mediator ($R^2 = 0.442$, $df = 2, 251, F = 49.342, p < 0.001$) is also significant. Although the path from procedural justice to NPD success is significant, there is also a significant indirect effect of procedural justice on NPD success through team reflexivity, as computed by the percentile bootstrapped confidence interval of the indirect effect $b = 0.285, SE = 0.0644, 95\% CI [0.167, 0.419]$. In the same way, the normal theoretical approach provided a $z$-test value of 4.443 ($p < 0.001$). Table 4 shows the results corresponding to the conditional process analysis.

When employing the conditional process analysis, the results show that the mediating effects of team reflexivity for the influences of existing knowledge, task familiarity, and procedural justice on new product performance success
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Discussion

Table 5 presents a summary of the results of hypotheses testing. All hypotheses from H1 to H6 are supported. Moreover, H7 is fully supported regarding the mediating role of team reflexivity on the relationships between existing knowledge, task familiarity, and NPD performance. But, contrary to our expectations, H7 is only partially supported with regard to the mediation role of team reflexivity in the relationship between procedural justice and NPD performance. Finally, H8 is partially supported, which indicates that the interaction term between task conflict and team reflexivity is not significant, while that between relationship conflict and team reflexivity is strongly significant.

Table 4: Mediation models results (conditional process analysis).

Table 5: Summary of the hypotheses testing.
clearly understand the NPD tasks are not recruited, then it is difficult to create a just atmosphere to promote team reflexivity.

Second, team reflexivity has a significant influence on NPD success. Existing knowledge and task familiarity can influence NPD success indirectly through team reflexivity. On the other hand, procedural justice can influence NPD success directly or indirectly through team reflexivity. For this reason, the full and partial mediation effects of team reflexivity impact the three main antecedents of NPD success.

Third, team conflict plays an important role in the influence of team reflexivity on NPD success. Previous studies indicate that team reflexivity can create learning and innovation, which can be very beneficial for NPD (Schippers et al., 2008). However, the results of this study indicate that as relationship conflict among NPD members becomes greater, the influence of team reflexivity on NPD success is significantly diminished. Team reflexivity can be categorized as a transitional phase in which teams plan, reflect, and review what they have done, analyzing further actions (Marks et al., 2001). However, according to Costa et al. (2015), in such a transitional phase, relationship conflict may be more harmful than at any other time. Undoubtedly, relationship conflict may inhibit the creative thinking of team members and their willingness to accept one another’s views, weakening the relationship between team reflexivity and NPD success. In contrast, the results of this study do not provide support for the moderating role of task conflict. Although the direction of influence is correct, because the nature of the tasks undertaken by team members may be very different (e.g., one team member may be responsible for marketing, while others may be responsible for production, finance, and administration), task conflict may not lead to any misrepresentation of the NPD team’s objectives, which suggests that the moderating effect of such conflict on the influence of team reflexivity on NPD success is not significant.

Implications for Research

The core proposition of the current research is that team reflexivity is crucial to improve team innovation and NPD. However, because of the nature of the teams, there are some contextual variables that moderate the aforementioned relationship, such as team conflict. This study thus extends the literature that claims reflection is one of the principal activities of information processing (Schippers et al., 2014). Because of the dynamic business environment, reflexivity may enhance the capacity of NPD teams to deal with new information about the market, consumer needs, and competitors, and thus better interact with the existing knowledge within the black box of information processing. Through greater reflexivity, NPD teams can better comprehend how to work together to develop better products or innovative processes by recognizing the relevance of both new and existing knowledge. This study thus addresses previous calls in the NPD literature to better understand how existing knowledge can be used in an effective form for the development of new products (Schippers et al., 2014).

The results of this study showed that existing knowledge, task familiarity, and procedural justice are important drivers of team reflexivity. Existing knowledge is a key element in the organizational learning that is part of the information processing in which NPD teams need to engage. Existing knowledge may determine the ease with which teams adopt new information, and thus how their reflection can turn into new products. Furthermore, this study argues that the subprocesses contained in team reflexivity should be identified with the aim of evaluating the relevance of existing knowledge and analyzing the formal procedures that can enhance team reflexivity. The results also showed that procedural justice was highly and positively associated with team reflexivity, suggesting that good perceived procedural justice may promote team members’ intrinsic motivation to participate in their tasks, and thus improve the way work is structured (Zapata-Phelan, Colquitt, Scott, & Livingston, 2009), further enhancing the capacity to achieve the desired goals (Podsakoff, Whiting, Podsakoff, & Blume, 2009). These findings are supported by social capital theory, which states that the social capital of individual team members plays an important role in improving their reflexivity and knowledge sharing.

By concentrating on the mediating effects of team reflexivity, this study provides a deeper understanding of how NPD projects benefit from existing knowledge, task familiarity, and procedural justice through team reflexivity. This work thus extends the literature by seeing existing knowledge, task familiarity, and procedural justice as resources that organizations may hold or establish, but that cannot directly influence NPD success. Moreover, in the current literature (Farnese & Livi, 2015), it is less clear how some specific processes of knowledge may impact an organization’s capacity to promote NPD. This study has proven the importance of team reflexivity as a mediator as a result of its role as a double-loop learning process that permits NPD teams to utilize the current knowledge that an organization has in an effective form, which then leads to the exploration of better practices and problem-solving behaviors, fostering NPD.

Additionally, team reflexivity does not depend only on team members’ task familiarity. Because of the nature of the NPD context, tasks are characterized by their complexity and lack of specific structures (Campbell, 1988). Based on cognitive fit theory, it can be argued that in order to accomplish their tasks, team members may be required to exhibit cognitive fit regarding the focal goals (John & Kundisch, 2015). Cognitive fit theory provides an important tool that improves problem solving in different
contexts, especially in more innovative ones. In an NPD context, there is a need to generate new ideas or solve creative problems. As a result, team reflexivity is a facilitator that boosts team members’ understanding of the current environment, enhancing the mental representations that team members can invoke to solve a problem. In addition, it seems that team reflexivity is also related to task structure (Campbell, 1988; Nouri et al., 2013; Rietzschel, Slijkhuys, & Van Yperen, 2014). A complex and unstructured task with which people are not familiar should elicit much higher team reflexivity. Conversely, a well-defined task might require different levels of reflexivity compared to a more unstructured task as a result of the diverse demands on the cognitive processes of the team members that the former will make, although this issue is one for further empirical validation.

Finally, this study contributes to the NPD and conflict literature by being among the first to empirically validate the proposition that contextual variables may moderate the relationship between team reflexivity and NPD success. In particular, the negative moderating effect of relationship conflict has new implications that were not found in the current literature. Specifically, both relationship and task conflicts are needed in NPD teams so that they do not fall into the comfort zone of group-think, which can hinder the analysis of different perspectives. This study thus proposes that organizations should work to manage the natural development of relationship conflict in order to leverage their reflexive capacities and so enhance NPD success. An additional insight of this work is that team reflexivity represents a transitional phase of team performance, in which team members evaluate their current progress and future plans. Moreover, in this phase, relationship conflict can hinder the link between team reflexivity and NPD success. However, it could be argued that the impact of team conflict could be different in another stage of the NPD process, and this is another issue for future research.

Implications for Practice
The current study has a number of managerial implications. Specifically, it sheds some light on the influences of team members’ existing knowledge, task familiarity, procedural justice, and team conflict on the relationship between team reflexivity and NPD success. First, the results show the importance of the above mentioned antecedents with regard to team reflexivity; thus, it is imperative that managers highlight the creation of NPD teams in which members hold sufficient existing knowledge about the products and procedures with which they are working. In order to do so, managers should analyze the type of knowledge that members have, recognize its nature, and further improve the strategies related to the different mechanisms needed to disseminate knowledge among team members (Zhou & Li, 2012). Through this analysis, managers may be able to decide whether their organizations should acquire new knowledge or simply implement more internal knowledge dissemination. Conversely, existing knowledge influences the task familiarity of team members. NPD team leaders may thus use existing knowledge and task familiarity as important standards in forming NPD teams.

Second, procedural justice is a key factor in stimulating team reflexivity. It is therefore important for managers to realize that procedural justice improves the working climate and also enhances team members’ perceptions of the fairness of the procedures related to NPD projects. Furthermore, procedural justice enables team members to perform better reflective activities. Overall, it is important for NPD team leaders to offer a nondiscriminatory working environment, because NPD projects are generally associated with high pressure and stress, and team members should be fairly rewarded based on their efforts. For example, managers should set up procedures and norms for NPD projects to ensure both fairness and flexibility in order to minimize misunderstandings among team members. Moreover, organizations can create spaces in which team leaders can communicate the objectives of NPD projects to the team members. This may allow team members to better comprehend the allocation of resources within the NPD project, which can increase the commitment of team members by decreasing negative perceptions with regard to the ways in which organizations handle such projects, and so enhance reflexivity within project teams (Li et al., 2007).

Third, although previous studies did not find any indirect effect of existing knowledge on team reflexivity (Lee & Sukoco, 2011), this study found that it had an important indirect effect on NPD success. Notably, existing knowledge, task familiarity, and procedural justice may indirectly influence NPD success; thus, these antecedents all deserve more attention when managers aim to develop team reflexivity in this context. Because of the prominent mediating role of team reflexivity, this study suggests that NPD project leaders should schedule systematic team meetings with the aim of promoting the continuous revision of NPD project objectives, examination of the proposed goals, and deep and open discussions regarding team performance (West, 2000). In these meetings, project leaders should aim to strengthen the work environment in order to make team members feel safe in their social interactions and information sharing.

Finally, NPD team conflict is critical not only for the success of NPD projects, but also for maintaining the desirable behaviors that enable successful NPD teams within organizations. More precisely, inefficient NPD projects are characterized by a lack of existing NPD knowledge, unfamiliarity with focal tasks, and insufficient procedural justice, all of which may decrease reflexivity and increase uncertainty among team members as a result of increased
conflict within NPD teams. Most previous studies have focused on the effects of team conflict on innovation (De Dreu, 2006; Song et al., 2006), but little attention has been paid to the interaction between team reflexivity and team conflict, and the effects of this on NPD success. This study found that relationship conflict is a key factor that can weaken the relationship between team reflexivity and NPD success.

Managers should thus work to enhance information exchanges and overall communication within NPD teams, especially in transitional phases, because ineffective or unnecessary interactions may trigger some relationship conflicts. Managers should also evaluate existing processes to improve the allocation of resources in order to reduce relationship conflicts within NPD teams. Furthermore, managers should carefully examine in which stage an NPD project is, and, based on this, either encourage or discourage the formation of task conflict.

Limitations and Future Research Directions

The present study reviewed the product innovation literature to develop a research framework that may be beneficial for both academics and managers. However, its conclusions should be generalized with caution because of the following limitations. First, this study obtained data from 254 team members using single informants to compute the measurement items. As a result of the single source, there is the possibility of some bias. This work also employed cross-sectional data. The use of longitudinal data in future studies would enable a better understanding of the evolution of team reflexivity over time. A future longitudinal study may also use different informant sources to increase the generalizability of its findings. In addition, although this study involves an NPD team-level concept, the unit of measurement is the perceptions of the team members. Thus, there is a possibility that the results are biased. With the examination of shared task familiarity and team reflexivity, there is an assumption in this study that the team members who took part in this work all shared the same view of these research constructs (Kozlowski & Klein, 2000). Therefore, future studies may aggregate the individual measures to team constructs.

Moreover, this study carried out a short and direct assessment of NPD success, decreasing the likelihood that proximal predictors influence more distant results (Chiocchio, Kelloway, & Hobbs, 2015). We employed NPD success measurement items that are similar to those developed by Akgün et al. (2006), but a more accurate measurement scale should be employed in further research. Finally, this research was carried out among high-tech firms in Taiwan. Therefore, the results cannot be applied to other cultures, and specifically to Western ones, without more work being done to assess the validity of this study’s findings in such contexts.

Conclusion

Management researchers in the field of NPD and innovation seem to be more aware of the necessity of NPD team projects for the development of successful products. Because of the dynamic nature of teams, interactions among team members may influence the extent to which team members share information and project-related perceptions. Therefore, this study aimed to apply a more dynamic view of teamwork by considering team reflexivity as an important information process that boosts the dynamics of teams by creating new arrangements of ideas and people that can better fit changing market demands (Humphrey & Aime, 2014). The goal was to emphasize the advantages of considering a contingency perspective that sees team conflict as a moderator that impacts the positive relationship between team reflexivity and NPD performance. At the same time, we highlighted the importance of understanding multiple practices to improve team reflexivity. Our results suggest that existing knowledge, task familiarity, and procedural justice enhance team reflexivity. Moreover, relationship conflict lessens the positive effects that team reflexivity has on NPD success.

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Influential Factors for Team Reflexivity and New Product Development


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ABSTRACT

Global integration, advances in information and communications technology, in addition to changing partnership models and structures, have led to the growing use of geographically dispersed project teams (GDPTs). However, relatively little is still known about the nature of barriers to tacit knowledge sharing in oil and gas projects. Consequently, this Delphi study explores the features of obstacles to tacit knowledge sharing in oil and gas project settings. The barriers were found to be personal, team, organizational, and external in nature. This article provides unique insights that can assist in the effective knowledge management across GDPTs in oil and gas projects.

KEYWORDS: knowledge sharing; GDPTs; tacit knowledge; oil and gas projects; Delphi technique

INTRODUCTION

The significant growth in the global demand for oil and gas products, without a reciprocal increase in the market supply of these commodities after the Great Recession ended in 2009, has stimulated an upsurge in their prices (Hoeven, 2011). As a result, oil and gas projects have increased substantially in number, size, and complexity over recent years. For instance, in Australia alone, there are about six ongoing large-scale investment gas projects with their combined worth put at A$180 billion according to the Australian Petroleum Production and Exploration Association (APPEA). The International Energy Agency (IEA) estimates new worldwide oil and gas infrastructure to cost US$20 trillion between 2011 and 2035 (Hoeven, 2011). There are many recently completed or existing oil and gas projects around the world. One of these is the US$136 billion’s Kashagan oil field project in Kazakhstan, estimated to produce 13 billion barrels of crude oil (Campaner & Yenikeyeff, 2008). Also, there is an ongoing A$54 billion Gorgon LNG project in Australia designed to provide natural gas of at least 9.6 trillion cubic feet (Australian Broadcasting Corporation, 2014; Olaniran, Love, Edwards, Olatunji, & Matthews, 2016). In Russia, two oil and gas megaprojects—Sakhalin I and II with a combined cost of about US$40 billion—were completed within the last decade (Krysiek, 2007). Moreover, Statoil’s Snohvit Liquefied Natural Gas was also executed in Norway at a cost over US$10 billion (Karlsbakk, 2008). Lastly, Shell’s Athabasca Oil Sands Megaproject in Alberta, Canada was finished at the price of US$14.3 billion in 2010 (Lewis, 2013).

Implementing large size and complex projects requires enormous, often limited and competitive resources (e.g., materials and equipment, and human), which are spread across multiple countries. To facilitate cost-effective management of these vast resources, various partnerships, cross-organizational functions, and then a drive toward decentralization and globalization of project activities and processes are vital (Bourgault, Drouin, & Hamel, 2008). This situation compels oil and gas corporations to build teams across many countries to ensure efficient utilization and control of the required resources for their project realization. In this article, these project teams that work across different spaces, locations, time zones, and cultural and organizational boundaries are referred to as geographically distributed project teams (GDPTs) (Hertel, Konradt, & Orlikowski, 2004).

GDPTs are prevalent in oil and gas projects. The growing use of GDPTs in these projects has been further encouraged and assured by the rapid expansion of information and communications technology (ICT) in recent times (Hinds & Mortensen, 2005). Information and communication technologies enable a vast number of project teams scattered in different countries,
Barriers to Tacit Knowledge Sharing

and even those located in outer space, to communicate, hold meetings, and exchange ideas toward completing their projects (Sessa, Hansen, Prestridge, & Kossler, 2003). These teams, although located in different countries with distinct cultures, often coming from different business units or organizations, are all expected to work, corporate, and interact closely to deliver project deliverables (Espinoza, Slaughter, Kraut, & Herbsleb, 2007; Mohrman, 1999). Despite being popularly used in the execution of oil and gas projects globally, GDPTs are difficult to manage and are predisposed to failure (Espinoza et al., 2007).

A notable feature of GDPTs is that, although the teams may meet physically once in a while, they work together mostly from different locations (Jarvenpaa & Keating, 2012; Mohrman, 1999). These teams, therefore, initiate, plan, execute, integrate, and control project activities using ICT applications such as videos conferencing, mobile phones, emails, webinars, and Skype among others. Of great importance to GDPTs, is the quality of knowledge sharing practice across the teams. The way information is disseminated and ideas exchanged across the teams may impact their ability to provide innovative solutions and facilitate mutual learning in their projects (Daim et al., 2012; Prikladnicki, 2012). Physical distance, coupled with the cultural differences and gaps in the applications or quality of technologies available to the GDPTs, may all influence the flow of communication among these teams (Ruuska, Arto, Aaltonen, & Lehtonen, 2009; Verburg, Bosch-Sijtsema, & Vartiainen, 2013). In addition, lack of immediate physical contacts may reduce awareness of project tasks, hinder effective coordination, and desired cooperation among team members especially if they are not adequately trained to work in such an arrangement (Ägerfalk, Fitzgerald, Holmström, Lings, Lundell, & Conchür, 2005). Such occurrence may lead to problems in the knowledge sharing behavior of the teams.

Organizational context, personality differences, motivational factors, interpersonal and team features, and national culture have been discovered previously as factors impacting knowledge sharing in teams (Wang & Noe, 2010). The influence of these factors may become more significant in GDPTs. For instance, a study by Hinds and Mortensen (2005) found interpersonal and team conflicts to be more prominent in GDPTs than in collocated teams (i.e., teams that work together physically). Conflict is not only prevalent in GDPTs, but it is also difficult to identify and manage (Hinds & Bailey, 2003; Mannix, Griffith, & Neale, 2002). Conflict arises in GDPTs due to different perspectives, lack of trust and shared identity, and unshared information, among others (Armstrong & Cole, 2002). Accordingly, knowledge sharing may be significantly impaired in teams that are prone to conflicts. However, research has suggested that a team charter that clearly establishes different behavior characteristics may be used to build trust within GDPTs (Kirkman, Rosen, Gibson, Tesluk, & McPherson, 2002; Mathieu & Rapp, 2009).

Issues related to knowledge sharing in organizational teams have been considered widely in the literature. However, limited research has examined the knowledge sharing behavior in GDPTs particularly in the context of oil and gas projects. With the increased use of GDPTs in the execution of oil and gas projects, there is a need to improve knowledge sharing practice among GDPTs. Such improvement is evidently desirable in the current falling price regime of oil and gas commodities as it can enhance knowledge management in GDPTs and generate a greater innovation for the better performance of these projects (Olaniran, Love, Edwards, Olatunji, & Matthews, 2015a). The importance of sharing tacit knowledge has been emphasized. According to Nonaka and Takeuchi (1995, p. 85), sharing of tacit knowledge among diverse people is crucial for “organizational knowledge creation to take place. An effective tacit knowledge sharing can be used by organizations to save their operating costs thereby reducing their product price and improving their profit margin (O’Dell & Grayson, 1999). According to O’Dell and Grayson (1999), Chevron was able to save US$2 billion in its operating expenses in seven years due in large part to its policy, which encourages tacit knowledge sharing among its employees. Similarly, Goh (2002) indicates that some organizations (e.g., Hewlett-Packard and 3M) incentivize sharing of tacit knowledge among their employees or teams toward improving their production or work processes, resulting in reduced effort and any associated costs.

Factors impeding explicit knowledge sharing within organizational teams have been covered extensively; however, those hindering the sharing of tacit knowledge have received less attention. Few past studies (e.g., Hendriks, 1999; Adler, 2001; Meyer, 2002; Lam & Lambermont-Ford, 2010) have identified the barriers to tacit knowledge sharing within organizations. Some of the factors found to be limiting tacit knowledge sharing in organizations include lack of trust among the workers and their unwillingness to share their experience. With the previous studies focusing more on knowledge sharing within organizational teams rather than project-oriented teams, despite the overall significance of the latter in the strategic competitiveness of any going concern (i.e., profitable business), there is a need to extend the current literature on this important area. Therefore, this study focuses on identifying those factors impacting negatively on the sharing of tacit knowledge in GDPTs. This research area is significant as it can promote the effectiveness and enhance the value of GDPTs as well as the delivery of oil and gas projects.
Accordingly, the primary research question is:

What are the perceived barriers to tacit knowledge sharing within geographically dispersed project teams (GDPTs) in oil and gas projects?

The central benefit of identifying these barriers is that oil and gas organizations can develop means of reducing them, thereby promoting cross-fertilization of ideas and increasing the value of their personnel’s expertise toward the successful delivery of their projects. To better understand the barriers to tacit knowledge sharing in geographically dispersed teams within hydrocarbon megaprojects, a Delphi survey of oil and gas professionals working in GDPTs was undertaken. Using the understanding developed from studies such as those from Yih-Tong Sun, and Scott (2005), Joia and Lemos (2010), Nesheim and Hunskaar (2015), and results obtained from the Delphi survey, this study proposes a certain number of knowledge sharing barriers that can be associated with GDPTs. These obstacles are suggested to be personal, team, organizational, and external in nature.

The importance of this study cannot be overemphasized. Tacit knowledge is necessary for facilitating learning and innovation across any project organization (Lam, 2000). Learning about the barriers that impede the tacit knowledge across GDPTs can be regarded as a crucial first step in breaking them. Such knowledge will enable GDPTs to enhance their learning and innovation capabilities through an active application of tacit knowledge (Lam, 2000). Breaking barriers to tacit knowledge within GDPTs can contribute significantly to success in oil and gas projects, embolden both technical and non-technical relationships between the parties involved, as well as translate to the even distribution of knowledge (Lam, 1997).

This article commences with a review of the existing literature on geographically dispersed project teams and knowledge sharing within the context of oil and gas projects. Following the consideration of an extant body of knowledge, this article describes the research approach adopted in this study, then the research key findings are provided. Finally, comments on the research limitations and its implications for oil and gas project management and research are presented.

**Literature Review**

This section provides in-depth descriptions of tacit knowledge sharing across GDPTs in oil and gas projects and first introduces the reader to the context of GDPTs in oil and gas projects. It then provides background information regarding tacit knowledge and its sharing in GDPTs.

**GDPTs in Oil and Gas Projects**

The increasingly sophisticated and complex environments under which contemporary oil and gas projects are being delivered, along with their exceptionally large size, present them with unique challenges. One of the chronic problems faced by these projects is cost overruns (Olaniran, Love, Edwards, Olatunji, & Matthews, 2015b). Typically, the resources and facilities needed to implement such large engineering and construction projects are neither concentrated in one location nor in one organization (Olaniran, 2015). This unique situation has led to the formation of multiple and cross-organizational partnerships in oil and gas projects to ensure an accessible pool of resources and facilities required for their execution. In the case of the Gorgon LNG project in Australia, the downstream and logistics part of the project was awarded to Kellogg Joint Venture (KJV), consisting of three partners with their operating and support centers spread across Australia, England, the United States, Singapore, Indonesia, and Japan (Lawson, 2009). Due to the lack of adequate resources in one location and environmental issue, KJV utilized many fabrication yards located across Southeast Asia and Australia during the implementation of this project (Clough, 2009). Because of their operating and support centers being separated by time and space, KJV would not have been able to coordinate its project activities without the use of dispersed geographically teams.

Oil and gas projects require a large pool of specialists that are hard to find. The recent transition to the exploration and production of “unconventional” oil and gas such as coal seam gas, gas-to-liquids, oil sand, and shale oil has placed peculiar demands for industry experts (Defeyes, 2008; Gordon, 2012). There are many projects around the world competing for a limited and skilled workforce nearing the age of retirement (Deloitte Access Economics, 2011). Meeting the demands for qualified personnel has become the most difficult challenge facing the implementation of oil and gas projects (Procaccini, Lea-Cox, & Scheffer, 2012). Thus, oil and gas corporations have resorted to the aggressive overseas recruitment of experts to solve this problem (McMullin, Cooke, & Downie, 2004) but such an exercise has its bottlenecks. For instance, in Australia, difficulty in obtaining working visas for foreign professionals has been identified as one of such constraints (Deloitte Access Economics, 2011; ManpowerGroup, 2011). With skilled labor required for these projects not readily available in one location, the use of GDPTs has become indispensable to achieving a competitive edge (Carrillo, 2004). Oil and gas projects are now characterized with GDPTs that work in collaboration with different contractors and construction teams, thereby necessitating global planning and coordination of project activities (Court & Hughes, 2013).

The use of GDPTs in oil and gas projects has been enhanced by the progress in the collaborative information and communication technologies. These technologies allow greater cooperation, collaboration, communication, and information management across dispersed teams (Zeimiansky, 2008).
Examples of collaborative information and communication technologies are project management systems (e.g., scheduling software, tracking system); online spreadsheet; client portals—software that allows teams to interact, share files, discuss, chat, plan, organize, and manage tasks and events in a private online environment (Neely, 2014); and project extranet—a website that allows monitored access to partners, vendors, suppliers, and other participants in a project (Wilkinson, 2005).

With an ever abundance of these technologies, oil and gas companies have embraced GDPTs. For example, Kvaerner structured its oil and gas design project in a way that the engineers located in Oslo, Abu Dhabi, Singapore, Korea, Monaco, Perth, and Fremantle could collaborate and work together (Munkvold, 2005).

Describing Tacit Knowledge

Previous attempts to provide a uniformly acceptable definition of knowledge have not been successful (Bhatt, 2000; Yih-Tong Sun & Scott, 2005). Knowledge has been defined variously by many researchers; one such definition is provided by Propp (1999, p. 227), who defines this concept as the “content and structure of the individual’s cognitive system.” Cognitive system is a mixture of “beliefs, attitudes, values, opinions, presumptions, and memories” used to create a meaning to a situation (Yih-Tong Sun & Scott, 2005, p. 75).

A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Fifth Edition, identifies the application of knowledge as the bedrock of project management practice (Project Management Institute, 2013). Being knowledge-intensive, availability and implementation or transfer of knowledge such as lessons learned, completed schedules, and earned value data from previous projects are crucial to the successful implementation of any oil and gas project (Garcia, Lessard, & Singh, 2014; Project Management Institute, 2013).

Knowledge is regarded as the most valuable asset for oil and gas projects (Edmundson, 2001; McKenna, Wilczynski, & VanderSchee, 2006). In most cases, project management offices (PMOs) are responsible for managing knowledge across teams (Julian, 2008). The importance of knowledge has been demonstrated with organizations reported to be spending, at any given time, an average of a trillion dollars annually to manage and a significant amount of time to build their knowledge resources and repository, respectively (Lohr, 2002). In recent years, companies have been spending money on project management software systems such as Primavera to create solid knowledge repository. It is debatable, however, if these software programs are appropriate for capturing tacit knowledge that has been described as elusive.

Two common forms of knowledge have been discussed in the literature: explicit and tacit. For many years, the focus of research was on explicit knowledge (Zhang, Ordonez de Pablos, & Zhang, 2012); however, in recent years, attention to tacit knowledge has been gaining momentum (Venkitachalam & Busch, 2012). Tacit knowledge was first presented in 1958 by Michael Polanyi (Panahi, Watson, & Partridge, 2013). Unlike explicit knowledge that can be easily codified and conveyed in the forms of written documents such as reports, technical drawings, manuals, and operating procedures (Reychav & Weisberg, 2009; Wei Choo, 2000), tacit knowledge is different. Tacit knowledge is individualistic in nature and cannot be possibly reduced to written documents (Goffin & Koners, 2011; Nonaka, 1994; Polanyi, 1967; Rosenberg, 1982). Such knowledge can be gained through learning by doing, as it is hard to communicate. Lam (1997, p. 976) depicts tacit knowledge with the following statement: “It is indeed a typical situation in our daily lives that a person can do something and yet is unable to explain how it is done. Tacit knowledge begins with an individual. For instance, a geologist may develop a unique understanding that helps create a better process for undertaking oil field investigation in a project. Such knowledge is transformed into project experience that cuts across and creates value for the project. Table 1 presents an overview of the various descriptions of tacit knowledge from some selected previous studies.

There are several examples of tacit knowledge in the literature—these include personal technical know-how or skill, insight, tricks of the trade, and interpersonal and negotiation skills, among others (Panahi et al., 2013; Smith, 2001; Tsoukas, 2011). These examples can fit into two dimensions of tacit knowledge proposed by Polanyi (1967) and illustrated further in Nonaka and Takeuchi (1995): technical and cognitive. The cognitive dimension of tacit knowledge includes beliefs, values, ideals, vision, goal, schemata, and mental models (Gore & Gore, 1999; Polanyi, 1997). Cognitive elements of tacit knowledge are embedded in us and we often do not know how to articulate them; however, this dimension of tacit knowledge molds our worldview (Lee, 2012). On the other hand, elements included in the technical aspect of tacit knowledge are informal personal expertise or know-how, problem-solving capability, and knowing-in-action, among others (Easterby-Smith & Lyles, 2011; Nonaka, 1994). Figure 1 indicates the distribution of examples of tacit knowledge across the two dimensions.

Tacit Knowledge Sharing

The descriptions of tacit knowledge in the last subsection have given weight to the potential significance of sharing this form of knowledge in highly specialized and complex oil and gas projects. Knowledge sharing is “the provision of task information and know-how to help others and to collaborate with others to solve problems, develop new ideas, or implement policies and procedures” (Wang & Noe, 2010, p. 117). The sharing of tacit knowledge is a practical means of translating specific
Authors | Descriptions of Tacit Knowledge
---|---
Zack (1999); Athanassiou and Nigh (2000); Clarke and Rollo (2001) | Experimental and intuitive. It is most effectively shared through face-to-face interaction and highly mutual conversation. Credibility and willingness of the knowledge holder impact its transferability among project teams.
Polanyi (1997); Choo (2000); Scott (2000); Grover and Davenport (2001) | Gained through direct observation, imitation, and practice. Something that we know but cannot tell. It is shared via informal stories analogies and metaphors.
Haldin-Herrgard (2000); Panahi et al. (2013) | Personal skill, entirely dependent on its holder; attached to the human mind and cannot be shared easily. It is deeply rooted in a person's experience and practice.
Lai (2005) | Unstructured in nature that makes its management and sharing through ICT tough in a project.
Selamat and Choudrie (2004) | Plays a significant role in improving individual and organizational learning, productivity, decision making, and competitive advantage for a project.
Reychav and Weisberg (2010) | Difficult to share among the project teams because it requires a great deal of time and effort to transfer knowledge among the teams.
Falconer (2006) | Can only be shared through physical meeting/chatting, apprenticeship, mentoring, and direct observation.
Rosenberg (1982) | Knowledge of techniques, methods, and designs that work in certain ways and with certain consequences, even when we cannot explain why.
Grant (1997); Rüdiger and Vanini (1998) | Manifest only in its application and not amenable to transfer. It is represented through nonarticulated knowledge.

**Table 1:** Descriptions of tacit knowledge.

Personal learning and skills into project assets (Dalkir, 2005; Foss, 2007). Such knowledge, if successfully transferred, can drive a sequence of opportunities for innovation for the projects. Sharing tacit knowledge is essential for creating changes, including those related to process and technical activities in projects because it is not a form of knowledge that is commonplace and can be gained or explained in precise terms. Thus, projects that cultivate grounds for sharing tacit knowledge have the competitive advantage of achieving greater success. For example, creativity and inspirations of project team members may lead to the development and cross-fertilization of ideas that create an exceptional platform for solving project problems or achieving better results.

The sharing of tacit knowledge involves the supply and receiving of knowledge (van den Hooff & De Ridder, 2004). In this sense, there must be someone who holds or carries the knowledge (i.e., knowledge emitter) and people or systems (i.e., knowledge receivers) that demand or are ready to collect and use the knowledge to advance the project performance or viability. Unlike explicit knowledge that can be easily transferred using a mediating medium such as ICT, research has suggested potential problems of transferring tacit knowledge using this approach. Teece (2000) and Holste and Fields (2010) indicate that face-to-face interaction remains the best method of sharing tacit knowledge. Given the absence of or reduced level of physical interaction in GDPTs, tacit knowledge sharing may be almost impossible in such work arrangements. Tacit knowledge can be shared in formal settings, such as training events or conferences;

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**Figure 1:** Two dimensions of tacit knowledge.

- **Cognitive**
  - Gut feeling, mental models, intuition, hunches, intelligence, emotions, insights, opinions, beliefs, ideas, goals, understanding, creativeness, assumptions, perspective, ideals, values, judgment, perceptions, paradigms, viewpoints, schemata, visions, routines, non-analytic behavior, inspirations, creativity, imagination, norms, culture, bias, decision making, flexibility, sequencing, anticipation, inhibition, theory of mind, emotional self-regulation, empathy, inhibition, ability to speak language, attentiveness, listening, leadership, innovation, aesthetic sense, sales and negotiation skills, body language, humor, and perceptiveness

- **Technical**
  - Hands-on experience, skills, expertise, tactical approach, best practices, lessons learned, tricks, tips, crafts, rules of thumb, knowing-in-actions, practical know-how, problem solving

(Adapted from Nonaka, 1995)
it can also be transferred informally during project activities involving different teams, informal social networks, and workers’ interactions (Holste & Fields, 2010; Marquardt, 1996). For both formal and informal tacit knowledge sharing to take place effectively in project teams, individuals must be ready and have the capacity to share their know-how or understanding and to use the skills acquired (Foos, Schum, & Rothenberg, 2006). Also, the cohesive environment is of utmost importance for sharing tacit knowledge as this may facilitate close interactions and cooperation among individuals. Improved team cohesion may enhance individuals’ motivation and tendency to share and receive tacit knowledge due to the strong bond among them.

As previously mentioned, tacit knowledge is problematic to transfer because it is elusive and hard to capture. The difficulty of sharing tacit knowledge often stems from a limited control over what is known (Wilson, 2002). For instance, individuals often do not even recognize what they know until there is a need to apply that knowledge to achieve a task or an outcome (Wilson, 2002). So when people do not recognize what they know, how can they see the need to successfully share such knowledge? Past studies have proposed barriers that may inhibit sharing of tacit knowledge (e.g., Nilomolu, Subramani, & Aldrich et al., 2001; Stenmark, 2002; Lucas, 2005). These limitations include individuals’ reluctance to provide and/or apply tacit knowledge; lack of awareness of the tacit knowledge possessed by individuals; inability to express tacit knowledge due to the exercise being mentally and physically challenging; and difficulty in contextualizing tacit knowledge in particular situations (Lucas, 2005; Nilomolu, Subramani, & Aldrich et al., 2001; Stenmark, 2002). Other important elements that have been indicated as potential obstacles for sharing tacit knowledge include distrust, fear of losing power, poor leadership, poor reward system, unsuitable information technology, and lack of training (Riege, 2005). In addition, lack of incentives has been suggested as the possible impediment for sharing tacit knowledge (Gupta & Govindarajan, 2000), yet some researchers have argued that giving incentives to individuals to share tacit knowledge can be counterproductive (McDermott & O’Dell, 2001; Tissen, Deprez, & Andriessen, 1998). Table 2 lists a summary of the potential barriers to tacit knowledge sharing.

### Research Approach

This section presents the method used to address the primary research question: What are the perceived barriers to tacit knowledge sharing within geographically dispersed project teams (GDPTs) in oil and gas projects? A research approach has been described as the systematic manner in which the problems associated with a study are solved (Flick, 2011; Mertens, 2014). In this study, a Delphi technique was adopted to gather and analyze data for investigating the barriers to tacit knowledge sharing in GDPTs.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Potential Barriers to Tacit Knowledge Sharing</th>
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<tbody>
<tr>
<td>Ipe (2003); Ding et al. (2007); Chow and Chan (2008); Zaglago et al. (2013)</td>
<td>Little trust, infrequent interaction, work apathy, individual personality, lack of knowledge sharing strategies, lack of reciprocity, and low job skills</td>
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<td>Boer et al. (2002); Hlupic et al. (2002); Hall (2001); Ardichvili et al. (2003); Hinds and Pfeffer (2003); Moffett et al. (2003); van den Hooff and De Ridder (2003)</td>
<td>Ineffective technologies and tools, motivations, organizational climate, communication environment, and cultures (organizational and ethnic)</td>
</tr>
<tr>
<td>Riege (2005)</td>
<td>Individual related barriers (e.g., lack of time to share and identify those in need of accurate knowledge, fear of job security, poor awareness and evaluation, and differences in experience levels), organizational related barriers (e.g., reduced or lack of organizational knowledge management strategy, lack of leadership or managerial commitment that encourages tacit knowledge sharing, and lack of corporate culture that supports tacit knowledge sharing), technology related barriers (e.g., weak or lack of integration of IT systems and processes that supports the knowledge sharing, and lack of staff training on using IT systems to facilitate the knowledge sharing)</td>
</tr>
<tr>
<td>Wang (2010)</td>
<td>National culture; organizational context (organizational culture, management support, incentives, and organizational structure); interpersonal and team characteristics (team processes, diversity, and social networks); individual features; and motivational factors (knowledge ownership, perceived benefits and costs, interpersonal trust and justice, and personal attitudes)</td>
</tr>
<tr>
<td>Nonaka and Takeuchi (1995); Argote and Ingram (2000); Nidumolu et al. (2001); Stenmark (2002); Foos et al. (2006)</td>
<td>Willingness to share and use tacit knowledge, limited awareness of the tacit knowledge an individual possesses, difficulty in expressing tacit knowledge that is tied to mental and physical action, and difficulty of applying context-specific tacit knowledge in other contexts. Fear of losing competitive advantage over peers</td>
</tr>
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Table 2: A summary of potential barriers to tacit knowledge.
The Delphi Technique

The Delphi method refers to an organized, multi-pass group decision procedure for addressing research questions for which there is the absence of straightforward answers (Keil, Tiwana, & Bush, 2002). Unlike interviews, the Delphi technique is regarded as an excellent empirical tool for gathering a dependable consensus of view from a group of individuals with expertise in a research area (Buckley, 1995; Okoli & Pawlowski, 2004). As a flexible and adaptable research method, the Delphi technique is suitable for a project management–related study that is focused on identifying problems as this method may assist in obtaining a bird’s eye view of the issues being studied (Skulmoski, Hartman, & Krahn, 2007). The approach adopted in this study was similar to those used in Keil et al. (2002) and Yih-Tong Sun and Scott (2005). A three-round Delphi process was undertaken. Figure 2 illustrates the research framework.

Sampling

The expert participants in the Delphi process were selected primarily through purposive sampling. In the purposive sampling method, respondents are chosen based on a researcher’s awareness that they possess expertise in the research area (Bruce & Howard, 2011). However, snowball sampling was also used to increase the number of expert group participants. Snowball sampling engages the initial group members in identifying additional members with comparable qualifications (Dooley, 2007). A total of 30 experts who have worked recently or are currently working in GDPTs in oil and gas projects were invited to participate in the Delphi process. However, 16 experts participated in the process, thereby representing a response rate of 53%; this number exceeded the recommendation of at least 13 expert panelists to achieve a sample reliability of 0.9 by Dalkey (2002). All the participants had at least five years experience in working in GDPTs. The anonymity of the expert participants was preserved throughout the process (Geist, 2010). Table 3 shows the demographic characteristics of the Delphi participants.

The Delphi Process

The Delphi process involved a total of three rounds of surveys in obtaining the opinions of 16 expert participants or panelists in the study. Three rounds of surveys are suggested as suitable to attaining a consensus (Geist, 2010). To enhance ease and adequacy of participation by the panelists, the survey information, survey questionnaire, and replacement questionnaire were delivered to them using an electronic mail system (Smyth, Dillman, Christian, & Mcbride, 2009). The panelists were identified as a busy set of people, so it was important that the process was made as convenient as possible.

The first round in the Delphi process—also known as the generative stage—encouraged the expert panelists to reflect and list their perceived barriers to tacit knowledge sharing in GDPTs based on their extensive experience working in such teams (Geist, 2010; Linstone & Turoff, 2002). In this instance, emails were sent individually to the panelists in deference to the principle of participants’ anonymity. In the emails, the panelists were also provided with background information about the research and definitions of key terms. For example, tacit knowledge was defined as the knowledge possessed by an individual that cannot be written down, communicated, or learned quickly except through observation, imitation, and practice; for example,
innovation, leadership, hands-on experience, and problem-solving skills (Goffin & Koners, 2011). Examples of such knowledge were provided to them as personal technical know-how or skill, insight, tricks of the trade, interpersonal and negotiation skills, beliefs, values, ideals, vision, goals, problem-solving capability, and knowing-in-action. The panelists were encouraged to reflect on more examples that could fit into the description of tacit knowledge and mentioned others, such as innovation, intuition, and leadership skills. This demonstrated that they fully understood the meaning of the concept. Also, knowledge sharing was referred to as the provision and receiving of information about unique know-how to assist others and to collaborate with others to address problems, develop new ideas, or implement policies and procedures (Wang & Noe, 2010). In this first-round survey, the panelists provided a list of 138 barriers in total.

The second stage of the Delphi process provided the expert panelists with the opportunity to rank the barriers compiled from round one. A total of 138 barriers generated from round one were given to the expert participants to rate based on their perceived impact of the obstacles to tacit knowledge sharing among the GDPTs. Using a five-point Likert scale, ranging from strongly agree to disagree strongly, expert panelists were asked to rank their agreement with each of the barriers generated from round one. Convergence of thinking was assumed for every barrier ranked in the top ten by over 70% of the expert panelists (Yih-Tong Sun & Scott, 2005). The analysis of the responses to the second-round survey was undertaken. Thirty-seven barriers emerged from the second round of the Delphi process after the analysis. Some of the high-ranking barriers were language problems across the GDPTs, concerns about the knowledge’s trustworthiness, and time constraints due to different local time zones. Also, some of the barriers that received low priority were individuals not realizing the tacit knowledge possessed; unawareness about the value of the tacit knowledge possessed; the disparities in age, gender discrimination, and different educational levels; and lack of social interactions. Table 4 presents the outcome of the second round of the Delphi process.

In the third and final round of the Delphi process, the 37 barriers obtained from the second set of the Delphi process were again presented to the expert panelists for re-ranking. A total of 29 barriers were returned from this round of survey using the same convergence standard employed in the second round of the Delphi process. To ensure representative opinion, the 29 barriers gathered after the analysis of the survey responses were then given to six members of the Delphi panel (each from six project types represented in the study population). The selected six participants at this stage were mandated to list potential sources of these barriers. The nature of the obstacles identified unanimously by the six-member panel were categorized as personal, team, organizational, and external. The classification of the barriers was based on which

<table>
<thead>
<tr>
<th>Panelist</th>
<th>Years of Experience in GDPTs</th>
<th>Role</th>
<th>Project Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panelist 1</td>
<td>6 years</td>
<td>Project Manager</td>
<td>Oil and Gas Field Development</td>
</tr>
<tr>
<td>Panelist 2</td>
<td>8 years</td>
<td>Senior Project Manager</td>
<td>LNG Facility</td>
</tr>
<tr>
<td>Panelist 3</td>
<td>7 years</td>
<td>Senior IT Consultant</td>
<td>Gas Field Development</td>
</tr>
<tr>
<td>Panelist 4</td>
<td>9 years</td>
<td>Project Planning Mgr.</td>
<td>Oil and Gas Production Facility</td>
</tr>
<tr>
<td>Panelist 5</td>
<td>6 years</td>
<td>Instrumentation Engineer</td>
<td>LNG Facility</td>
</tr>
<tr>
<td>Panelist 6</td>
<td>5 years</td>
<td>Scheduling Manager</td>
<td>Coal Seam Gas</td>
</tr>
<tr>
<td>Panelist 7</td>
<td>5 years</td>
<td>Senior Manager (Governance)</td>
<td>LNG Facility</td>
</tr>
<tr>
<td>Panelist 8</td>
<td>10 years</td>
<td>Senior Cost Control Engineer</td>
<td>Oil Field Development</td>
</tr>
<tr>
<td>Panelist 9</td>
<td>9 years</td>
<td>Project Manager</td>
<td>Oil and Gas Field Development</td>
</tr>
<tr>
<td>Panelist 10</td>
<td>6 years</td>
<td>Senior Project Manager</td>
<td>Oil Pipeline</td>
</tr>
<tr>
<td>Panelist 11</td>
<td>8 years</td>
<td>Senior Pipeline Engineer</td>
<td>Oil Pipeline</td>
</tr>
<tr>
<td>Panelist 12</td>
<td>7 years</td>
<td>Project Engineer</td>
<td>Gas Field Development</td>
</tr>
<tr>
<td>Panelist 13</td>
<td>9 years</td>
<td>Construction Manager</td>
<td>Gas Field Development</td>
</tr>
<tr>
<td>Panelist 14</td>
<td>7 years</td>
<td>Construction Manager</td>
<td>LNG Jetty</td>
</tr>
<tr>
<td>Panelist 15</td>
<td>5 years</td>
<td>Project Manager</td>
<td>Gas Production Facility</td>
</tr>
<tr>
<td>Panelist 16</td>
<td>6 years</td>
<td>Fabrication Manager</td>
<td>Oil and Gas Production Facility</td>
</tr>
</tbody>
</table>

Table 3: Demographic characteristics of the Delphi participants.

1The complete list of the supplied barriers generated in the first round is not included in this article due to space constraints but can be provided upon request.
<table>
<thead>
<tr>
<th>Barriers to Tacit Knowledge Sharing</th>
<th>Percentage of Panelists that Ranked the Barriers in the Top 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of personal desire for knowledge among the GDPT members</td>
<td>81%</td>
</tr>
<tr>
<td>Language problems across the GDPTs</td>
<td>100%</td>
</tr>
<tr>
<td>Poor informal collaboration across the GDPTs</td>
<td>84%</td>
</tr>
<tr>
<td>Differences in individual educational backgrounds</td>
<td>72%</td>
</tr>
<tr>
<td>Lack of mutual trust among the individuals</td>
<td>93%</td>
</tr>
<tr>
<td>Disunity or conflicts across the GDPTs</td>
<td>79%</td>
</tr>
<tr>
<td>Personalization of team achievement</td>
<td>77%</td>
</tr>
<tr>
<td>Unwillingness to use the available communication channels to share the knowledge</td>
<td>71%</td>
</tr>
<tr>
<td>Personal attributes</td>
<td>96%</td>
</tr>
<tr>
<td>Team attributes</td>
<td>100%</td>
</tr>
<tr>
<td>Tendency to personalize knowledge for competitive advantage</td>
<td>87%</td>
</tr>
<tr>
<td>Time restraints due to different local time zones</td>
<td>100%</td>
</tr>
<tr>
<td>Lack of shared vision</td>
<td>94%</td>
</tr>
<tr>
<td>Lack of known platform or sensitization for the knowledge sharing</td>
<td>74%</td>
</tr>
<tr>
<td>Organizational obligations</td>
<td>97%</td>
</tr>
<tr>
<td>Lack of organizational support for the knowledge sharing</td>
<td>89%</td>
</tr>
<tr>
<td>Tendency to preserve one’s knowledge for economic advantage such as employment</td>
<td>98%</td>
</tr>
<tr>
<td>Conflicting interests among the team members</td>
<td>76%</td>
</tr>
<tr>
<td>Fear of individuals losing the knowledge ownership</td>
<td>95%</td>
</tr>
<tr>
<td>Concerns about the trustworthiness of the knowledge</td>
<td>100%</td>
</tr>
<tr>
<td>Reduced individual attitude toward exchange of ideas</td>
<td>73%</td>
</tr>
<tr>
<td>Concerns about the acceptance of the knowledge</td>
<td>72%</td>
</tr>
<tr>
<td>Lack of motivation or interest among individuals</td>
<td>76%</td>
</tr>
<tr>
<td>Fear of losing credibility</td>
<td>94%</td>
</tr>
<tr>
<td>Reduced opportunity of interacting privately among the team members</td>
<td>100%</td>
</tr>
<tr>
<td>National cultural differences</td>
<td>97%</td>
</tr>
<tr>
<td>Concerns that knowledge shared in GDPTs may be critically scrutinized across the teams</td>
<td>100%</td>
</tr>
<tr>
<td>Lack of trusted communication methodology among the GDPT members</td>
<td>94%</td>
</tr>
<tr>
<td>Lack of trusting knowledge about GDPT members</td>
<td>96%</td>
</tr>
<tr>
<td>Lack of individual capacity to use the available technology options to share the knowledge effectively</td>
<td>72%</td>
</tr>
<tr>
<td>General perception that all GDPT members are experts and so reduced chances of knowledge sharing</td>
<td>79%</td>
</tr>
<tr>
<td>Lack of general sense of security</td>
<td>81%</td>
</tr>
<tr>
<td>Poor individual concentration due to frequent multitasking in GDPTs</td>
<td>74%</td>
</tr>
<tr>
<td>Short duration of interactions among GDPT members</td>
<td>92%</td>
</tr>
<tr>
<td>Lack of set-up processes for sharing the knowledge</td>
<td>78%</td>
</tr>
<tr>
<td>Lack of openness to sharing the knowledge among the team members</td>
<td>88%</td>
</tr>
<tr>
<td>Competitiveness among individuals and across organizations</td>
<td>95%</td>
</tr>
</tbody>
</table>

Table 4: The outcome of the second round of the Delphi process.
Barriers to Tacit Knowledge Sharing

Barriers to Tacit Knowledge Sharing | Nature
--- | ---
Lack of personal desire for knowledge among the GDPT members; personalization of team achievement; personal attributes; tendency to personalize knowledge for competitive advantage; tendency to preserve one’s knowledge for economic advantage such as employment; concerns about the trustworthiness of the knowledge; concerns about the acceptance of the knowledge; lack of openness to sharing the knowledge among the team members; fear of individuals losing the knowledge ownership; and fear of losing credibility | Personal
Language problems across the GDPTs; time restraints due to different local time zones; competitiveness among individuals and across organizations, and national cultural differences | External
Poor informal collaboration across the GDPTs; disunity or conflicts across the GDPTs; team attributes; and lack of set-up process for sharing the knowledge | Team
Lack of mutual trust among the individuals and teams; unwillingness to use the available communication channels to share the knowledge; lack of shared vision; conflicting interests among the GDPTs and their members; reduced opportunity of interacting privately among the team members; concerns that knowledge shared in GDPTs may be critically scrutinized across the teams; lack of trusted communication methodology among the GDPT members; lack of trusting awareness of the knowledge possessed by the GDPT members; and short duration of interactions among GDPTs and their members | Personal, Team
Organizational obligations; and lack of organizational support for the knowledge sharing | Organizational
Lack of general sense of security | Personal, Team, and Organizational

Table 5: The barriers to tacit knowledge sharing in the GDPTs and their nature.
these project settings to be personal, team, organizational, and external.

Issues related to personnel in GDPTs appear to be one of the significant obstacles to tacit knowledge sharing. Individual disposition is necessary for facilitating distribution of this form of knowledge (Joia & Lemos, 2010). For tacit knowledge sharing to occur, there must be individuals who are willing to share their know-how as well as those ready to receive the expertise (Smith, 2001). The involvement of these individuals in tacit knowledge is influenced by some prevailing conditions. For example, these people are bound by the cultures and principles of various organizations or business units they represent in the GDPTs (Rebentisch & Ferretti, 1995). The manners in which team members conduct themselves in GDPTs are usually embedded in their organizational orientation. According to Lam (1997), organizations have unique knowledge designs that can influence the extent to which knowledge can be transferred. So, if their organizations have strict restrictions vis-à-vis sharing a certain form of tacit knowledge, these personnel will likely refuse to transfer such knowledge. It should, however, be noted that organizations are increasingly becoming aware of the importance of knowledge management, delegating the duty to their PMOs (Gasik, 2011). To this end, project management offices have institutionalized different strategies, such as offering incentives to enhance knowledge sharing across project teams (Linder & Wald, 2011). The impact of such action on the tacit knowledge needs to be established.

This study also identified the barriers to tacit knowledge sharing as relating to the team nature. In this instance, team settings are suggested as having a significant influence on the exchange of tacit knowledge. According to Zakaria, Amelinckx, and Wilemon (2004), the settings of virtual teams are affected by their nature and culture. Team nature can be defined as its inherent characteristics such as its environment and structure (Holste & Fields, 2010). Team culture, on the other hand, refers to behaviors or ways of doing things within it, for example, procedures adopted in meetings and in decision making (Sánchez & Yurrebaso, 2009).

Holste and Fields (2010) and Sánchez and Yurrebaso (2009) suggest that both team nature and culture can impact on the tacit knowledge sharing potentiality in GDPTs. For example, if team culture does not support good informal interactions among members, tacit knowledge sharing may be negatively affected. Even if team members attempt to share their expertise, fear of this kind of gesturing being poorly received due to the team orientation may hinder them. If the settings of GDPTs are not designed to facilitate sharing of tacit knowledge, individuals may be reluctant to participate in this exercise. The outcome of this study suggests that barriers to tacit knowledge sharing are tied to team settings regardless of how individuals themselves are open to this activity. This result agrees with Yih-Tong Sun and Scott (2005) who identified team settings as one of the major problems confronting knowledge transfer in organizations.

The results of this research suggest that barriers to tacit knowledge sharing can be linked to organizational perspectives. This outcome also aligns with Yih-Tong Sun and Scott (2005) and Griffith et al. (2003), who found issues affecting knowledge transfer to be related to organizational settings and culture. Often, individuals who work in GDPTs originate from different organizations or business departments and as such bring their own organizational rules and cultures to the teams. For instance, some organizations prevent unrestricted sharing of knowledge without following certain protocols (Kwok & Gao, 2005). Such situations may limit the willingness of people to exchange tacit knowledge in GDPTs. Organizational culture and settings that support employees who work in GDPTs sharing their tacit, knowledge are crucial for this activity to occur.

Finally, external factors such as differences in language and national culture were found to constitute barriers to tacit knowledge sharing in GDPTs. This study has demonstrated that these external variables can affect the process of tacit knowledge sharing. For example, when some members of GDPTs have a functional proficiency in English, this situation may hinder their ability to participate successfully in a tacit knowledge sharing activity that involves the native language speakers. Competitiveness due to social and economic outlooks may also prevent tacit knowledge sharing. The importance of this sentiment has been demonstrated in the literature. Ardichvili et al. (2006), for instance, found a high degree of competitiveness to be a serious obstacle to knowledge sharing among Chinese teams. The barriers that are external in nature can be difficult to manage across GDPTs because they are usually beyond the control of individuals and groups.

Research Limitations

The findings of this study must be interpreted with full consideration given to its limitations. First, this study is exploratory in nature, and additional future research will be needed to validate the results presented. In light of this development, this study cannot be said to have adequately addressed underlying uncertainty regarding tacit knowledge sharing in GDPTs. Second, the research has statistical or data limitation due to a small number of participants in the survey. However, data limitation in this study arose from the research design, because the Delphi survey is oriented to utilizing a small sample. It is believed that the research outcome could have been different with a larger data size, for example, over 200 participants. Third, this study has been limited to participants from oil and gas projects. Therefore, results gathered from this study cannot be easily generalized to all the project teams.
the research findings could have been entirely different with participants from information technology (IT) projects. Bearing in mind the limitations of this study, “moderatum generalization” of its findings is proposed (Payne & Williams, 2005). Notwithstanding the constraints, its exploratory value should not be overlooked as well as the opportunities it presents for other researchers to improve in this research area.

Implications for Research and Practice
This study has some implications for research and practice in tacit knowledge sharing among GDPTs in oil and gas projects. These implications are discussed in this section.

Implications for Research
As typical with many studies and based on its limitations, this research raises more issues than it addresses; however, these problems provide opportunities for future research. The implications of this study for future research are fourfold.

First, there is an implicit degree of ambiguity with regard to the most practical approach for sharing tacit knowledge in GDPTs. Thus, it is suggested that further research should be conducted to unveil the processes that can practically support unhindered tacit knowledge sharing across GDPTs in oil and gas projects. This action is important, because the tacit knowledge itself has been described as mostly difficult to transfer despite its importance for project innovation. Without designing functional processes and platforms that individuals who work in GDPTs can use for sharing tacit knowledge, such know-how will remain unshared for the project benefits.

Second, there is a need for future research that focuses on identifying individual personality traits that are specific to people who are willing to share their tacit knowledge. The outcome of such study can then be used to design approaches to breaking barriers to tacit knowledge sharing. Additionally, case studies can be conducted to identify how problems of tacit knowledge sharing associated with particular organizational and national culture have been resolved in the past. Lessons acquired from studies can also be applied to formulate ways of addressing the barriers to tacit knowledge sharing identified in this study.

Third, as already highlighted in the research limitations, this study has employed a small data size. Future research should use large-scale data that present opinions from a wider range of participants in GDPTs. For instance, views of junior-, middle-, and senior-level managers in oil and gas projects could be sought altogether to arrive at a more logical conclusion. Such research could also apply more rigorous research design to gather data such as triangulation of two or more methods for results validation purposes.

Fourth, the next research agenda should attempt to replicate this study in other project settings such as information technology, research and development, and healthcare. Although this study speculates that its findings are valuable and potentially valid for other project settings, they are mostly restricted to oil and gas projects. Therefore, it is recommended that the research on barriers to tacit knowledge sharing should be undertaken in other project settings to invite more lessons that could help improve understanding of this research area.

Implications for Practice
It is important to reiterate that the findings of this study are context specific due to the research data being gathered from oil and gas project practitioners. Therefore, the research results present some implications for oil and gas project management practice; however, the consequences may be viewed differently by professionals in these project settings.

Foremost, there is a high tendency that professionals will be careful of the potential impact of their participation in tacit knowledge sharing across GDPTs in oil and gas projects. If they believe sharing their know-how will compromise their team or organizational obligations and laid-down principles, they may be reluctant to get involved in this activity. This situation is in line with the findings of this study. Although this may appear obvious, project managers do not often recognize how specific project standards or requirements can inhibit sharing of expertise across geographically dispersed teams; for instance, when platforms for sharing information are too formal or where members of GDPTs are requested to subject their opinions to formal assessment. In such situations, individuals may rather decide to keep their expertise to themselves because they fear being rejected. It is therefore suggested that project managers and other decision makers in the management of GDPTs should create a sound basis for promoting open knowledge sharing across these project settings. Such action would stoke the willingness of members of these teams to “give out” and “receive” among themselves, thereby encouraging innovations.

The findings of this study also pose questions regarding the level of awareness about the external factors that discourage tacit knowledge sharing across GDPTs in oil and gas projects. Project managers and others with authority over these project settings need to keep themselves abreast of external factors that could potentially weaken the desire of individuals to share their knowledge in such work environments; language can be one of such external barriers. People who are part of GDPTs cut across different countries with separate national languages. Individuals who predominantly speak Chinese may find it difficult to share their “hands-on experience” with those who speak English due to language differences. It is recommended that project managers and other higher authorities should construct GDPTs in a manner that allows individuals to interact closely and informally despite the diversity in their communicating.
language. For example, language interpreting functions could be embedded in the online communicating media used by individuals in GDPTs. Taking such steps will drive beneficial interactions between people and, consequently, strengthen their participation in the tacit knowledge sharing.

Conclusion

Academic research on knowledge sharing has focused more on explicit knowledge than tacit knowledge. The exchange of tacit knowledge, however, is necessary for project innovation to occur. Such knowledge transfer is particularly required and significant for GDPTs in which members do not meet face-to-face in the course of undertaking the project activities. Due to the dynamics of GDPTs, tacit knowledge sharing can be difficult. This article has identified the nature of barriers to tacit knowledge sharing across GDPTs in oil and gas projects to be personal, team, organizational, and external.

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Barriers to Tacit Knowledge Sharing


Barriers to Tacit Knowledge Sharing


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The Impact of Emotional Intelligence, Project Managers’ Competencies, and Transformational Leadership on Project Success: An Empirical Perspective

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ABSTRACT

Project stakeholders always strive for a successful project, hence there is growing concern about the factors that influence project success. Although the success of a project is influenced by various factors, project managers play a very important role. This study aims to examine the relationship and impact of construction project managers’ emotional intelligence (EI), managerial competencies, and transformational leadership style on project success. A total of 107 Pakistani construction firms were studied with a view to measuring the effects of these variables on the overall performance of construction projects. The results show that project managers with high emotional intelligence who bear the desired competencies and exhibit transformational leadership behavior are effective leaders and ensure higher success in projects than their counterparts. The findings will assist project sponsors in selecting the appropriate project managers for their projects.

KEYWORDS: emotional intelligence; transformational leadership; project managers’ competencies; project success; construction industry

INTRODUCTION

A n unsuccessful project results in losses to project stakeholders. Unfortunately, many projects fail to be completed within their scope, schedule, budget constraints, thereby ensuring the desired quality and satisfaction of all stakeholders in the construction industry. A study conducted by Standish Group International (2009) reported that the project success rate dropped from 34% in 2004 to 32% in 2009. Papke-Shields, Beise, and Quan (2010) surveyed 600 organizations across 22 countries and found that project outcomes of 86% respondents fell short of planned expectations; thus, there is growing concern about the factors that influence project success.

The results of recent research highlight the elusive trends of project success. According to Davis (2014), a variety of factors play leading roles in successful construction projects, including the technical expertise of project managers and project teams, communication skills, and so forth. Much of the earlier literature focused on the technical skills associated with project managers (Hyvari, 2006; Brown, 2000; Gale, 1999; Pinto & Kharbanda, 1995; Thamhain, 1991), and technical expertise continues to be well addressed as more and more project managers are becoming certified and entering the field. According to Strohmeier (1992), project managers spend approximately 88% of their working hours interacting with different stakeholders. Such huge interaction calls for those project managers who can lead effectively in addition to managing conflicts so as to build better relationships, thus ensuring success in their projects (Lewis, 1998). As Lechler (1998, p. 205) stated: “When it comes to project management, it’s the people that count.” As a result, there has been a shift from a technical bias (project managers’ technical skills) to project manager behaviors (soft skills) (Leybourne, 2007). Pant and Baroudi (2008) observed, however, that the training of project managers still focuses on hard skills, although the desire for human skills for successful project managers has already been recognized.

With regard to the human side of project management, much has been highlighted on identifying the skills, technical expertise, attributes, and
qualities required for a successful project manager. For example, the International Project Management Association (IPMA) Competence Baseline (2006) classifies 46 competency elements into three groups: contextual, behavioral, and technical competencies. The Project Management Competency Development Framework – Second Edition, published by Project Management Institute (PMI) (2007) describes project manager competency in terms of knowledge, performance, and personal competence. The Association for Project Management (APM) Competence Framework (2008) is similar to the IPMA Competence Baseline, but has some different competence elements. These are comprehensive studies; as project managers maintain the progress, the mutual interactions and tasks of the various parties, there will continue to be a need for an in-depth study on the human side of project management.

A study on the relationship styles of Hong Kong’s construction managers highlighted that human skills were of the utmost significance in project management (Rowlinson, Ho, & Yeun, 1993). Sunindijo, Hadikusumo, and Ogunlana (2007) also emphasized that human factors assume critical importance in ensuring project success. Unfortunately, these soft skills (the human side of the projects) have not received sufficient consideration in the project management literature (Skulmoski & Hartman, 2010; Hyvari, 2006). Gehring (2007, p. 50) posited that “. . . to increase the probability of project management success, the project manager must understand the leadership competencies that are required and what personality traits he or she has that compliments or competes with these competencies.” Dvir, Sadeh, and Malach-Pines (2006) highlighted the significance of aligning a project manager’s management style and personality with project type. Thal and Bedingfield (2010) found connections between personality traits and project manager success. Although we value these specific analyses, we believe that an extended scope of behavior dimensions (project managers’ soft skills)—through a larger, theoretical model—is needed for an entire view of the significant role different behavioral aspects play in project management. There arises the following research question:

What are the relevant aspects of project managers’ soft skills in project success and their connections?

In the next section, we identify the relevant aspects of project managers’ soft skills in project success and provide a theoretical background on the linkage of project success with emotional intelligence, project managers’ competencies, and transformational leadership. The model presented in the subsequent section hypothesizes the influence of project managers’ soft skills on project success. Our empirical investigation is based on the construction industry sample of 107 medium-sized and large firms. We collected data from each firm using a standardized questionnaire. After descriptions of the research setting and employed methods, we present our empirical results. The study concludes with a discussion of the findings and further avenues for research.

Hypotheses Development

Studies have revealed that the project manager’s role is vital to project success; however, the literature has largely ignored the effects of emotional intelligence (EI), project manager’s competencies, and his or her leadership approach to project success (Turner & Müller, 2005; Avolio & Yammarino, 2013). In order to carry out an in-depth study on the impact of these factors on project success, the following section will construct the relevant hypotheses.

Emotional Intelligence and Its Linkage to Project Success

“Emotional intelligence” (EI) is the “ability to monitor one’s own and others’ feelings and emotions, to discriminate among them and to use this information to guide one’s thinking and actions” (Salovey & Mayer, 1990, p. 189). With the research findings on the contributing factors for individual success from the field of psychology, the business world has also followed suit in identifying components of intelligence, other than the IQ (Intelligence Quotient) score (Gardner & Stough, 2002). Consequently, with the awareness of their own emotional intelligence and the eagerness to guide one’s own feelings and actions, individuals were asked to monitor themselves and others for optimum self, team, and organizational performance (Goleman, 2001).

The importance of emotional intelligence has been studied in the project management literature (Adams & Anantatmula, 2010; Clarke, 2010; Othman, Abdullah, & Ahmad, 2009; Geoghegan & Dulewicz, 2008). According to Salovey and Mayer (1990), researchers are deliberating on the important aspects of the human personality; in other words, emotional intelligence, along with leadership style, and their roles in achieving organization excellence. Carmeli (2003) also found that emotionally intelligent senior managers perform their jobs better compared with their peers with lower emotional intelligence. In the field of project management, Mount (2006) assessed the skills related to the success of project managers in 74 international petroleum corporations, and found that, of all the skills that contributed to project managers’ success, 69% were the emotional competencies (self-confidence, influence, achievement orientation, teamwork, and coordination); 31% were business expertise; whereas there was none (0%) in the area of cognitive skills, such as conceptual or analytical thinking. Another study by Geoghegan and Dulewicz (2008) was carried out to identify whether a significant relationship existed among emotional quotient (EQ) dimensions (self-awareness, sensitivity, influencing, and motivation) and project success. Having analyzed the data gathered from 52 project managers in the United Kingdom, the
Impact of Emotional Intelligence, Project Managers’ Competencies, and Transformational Leadership on Project Success

Researchers found a significant relationship between EQ dimensions and project success. Turner and Lloyd-Walker (2008) reported that emotional intelligence capabilities greatly contribute to project success.

In their study, Müller and Turner (2007), found a significant correlation between successful project managers’ three EQ sub-dimensions (consciousness, sensitivity, and ability to communicate) and project success. Later, they studied the leadership competency profiles of 400 successful project managers from all around the world (Müller & Turner, 2010). They used the leadership development questionnaire, based on the model by Dulewicz and Higgs (2005) and a compound measure of project success (ten success criteria), and found correlations among leadership competencies and project success. The result indicated that the EQ sub-dimensions (influence, motivation, and consciousness) of successful project managers significantly contributed to their success in all types of projects (Müller & Turner, 2010).

In their study, Yang, Huang, and Wu (2011) found that teamwork exhibited significant influence on project performance, whereas teamwork is an emotional intelligence competency included in the emotional intelligence competency model from Goleman, Boyatzis, and McKee (2013). Zhang, Zou, and Zillante (2013) found that Chinese construction project managers considered eight emotional intelligence competencies to be important for the successful management of their projects. These included empathy, inspirational leadership, teamwork and collaboration, conflict management, influence, change catalyst, service orientation, and organizational awareness. Rezvani et al. (2016) conducted their study on the Australian defense industry and reported the significant relationship between project managers’ emotional intelligence and project success with the mediation role of job satisfaction and trust. The studies of Pryke, Lunic, and Badi (2015) and Sunindijo et al. (2007) identified that the role of emotional intelligence is useful in leader-follower communication and leads to enhanced project performance. Sunindijo (2015) reported that emotional intelligence has a significant influence on project cost performance and project quality performance.

Therefore, we hypothesize the following:

**H1:** Emotional intelligence has a significant positive effect on project success.

**Project Managers’ Competencies and Their Linkage to Project Success**

Goleman et al. (2013) defined competencies as the potential of emotional intelligence translated into practical capabilities; in other words, these are the learned capabilities built upon emotional intelligence that result in exceptional performance. Mount (2006) studied the relationships among emotional intelligence and project managers’ competencies. His study was aimed at identifying the job competencies associated with the higher performance of project managers. He collected data on job roles performed by 74 construction project managers through range of data collection techniques. Druskat and Druskat (2006) put forward arguments suggesting that the characteristics of projects placed particular emphasis on project manager behaviors associated with communication, teamwork, building interpersonal relationships (attentiveness), and managing conflict. To support this argument empirically, this work was taken on by Clarke (2010), who combined these competencies with the behavioral items within project management. Clark (2010) selected items from the *Project Manager Competency Development Framework – Second Edition* (Project Management Institute, 2007) and grouped 24 project management behaviors into four project management competence domains; namely, communication, team work, attentiveness, and managing conflict. Clarke concluded that his study’s results suggested that emotional intelligence ability and empathy explain the individual differences among project managers that influence their better performance. For this study, project managers’ competency elements as studied by Clarke (2010) will be considered.

Ekrot, Kock, and Gemünden (2016) found that project management competence retention (PMCR) is positively associated with average project success of the organization. They further explained that project management competence retention is obtained by formal development perspectives in project management, such as a career path or qualification opportunities, as well as establishing a formal lessons learned system. Brière, Prouix, Flores, and Laporte (2015) found that project managers’ competencies are very important during crucial project changes and these are important for project management capacities. Whereas the study of Loufrani-Fedida and Missonier (2015) that the project managers’ competency factor works as a complement to organizational competencies, but it is not so useful if used as an alternative to organizational competencies.

Thus, the role of project managers’ competencies along with organizational competencies is vital in improving project performance. Some knowledge, skills, and abilities have emerged as especially relevant to the success of all projects, regardless of project size or complexity; these include participation, documentation, implementation, development, maintenance of quality assurance processes, critical thinking, project reviews, communication, leadership, and flexibility (Gallagher, Mazur, & Ashkanasy, 2015). In sum, we formulate the following hypothesis:

**H2:** Project managers’ competencies have significant positive effects on project success.

**Transformational Leadership and Its Linkage with Project Success**

The project manager’s role as leader is not reactive, but rather a proactive one. Müller, Geraldi, and Turner (2012)
stated that the important soft-success factor in any project is the role of the project manager as a leader, rather than a manager. Project managers do require having the requisite skills to lead their subordinates, which facilitates workers in achieving the project goals (Samáková, Sujanová, & Koltnerová, 2013). The project manager should be forward thinking, try to anticipate where things may veer off track, in order to take the necessary steps to prevent problems or, if unavoidable, try to recover from those problems as soon as possible (Avolio & Yammarino, 2013). As leader, a project manager must know and satisfy people’s needs; understands what drives people; and promotes their interests while pursuing the project’s objectives. Additionally, he or she must be aware of his or her own weaknesses and strengths so as to make the appropriate decisions while managing conflicts. It is correctly said that human behavior is the most interesting part of management but it is also the most challenging (Leban & Zulauf, 2004); and therefore, in the case of project managers, managing human behavior may be regarded as the most difficult management task (Leban & Zulauf, 2004). This requires project managers to display effective leadership qualities in order to lead their team members toward the achievement of desired performance. Burns (1978) developed the Transformational–Transactional Leadership Model, in which he defined transformational leaders as those who inspire their subordinates and provide intellectual challenges. He stated that transactional leaders focused on daily routine activities as an exchange between themselves and subordinates. Later, this model was further expanded upon by Bass and Avolio (2000), who included another type of model, called “laissez-faire.”

Goleman (2003, p. 94) highlighted that “effective leaders are alike in one crucial way: they all have high degrees of emotional intelligence.” He argued that effective leaders possess the ability to employ the right type of leadership for the prevailing situation in the organization. Transformational leadership style has been studied by most researchers with many positive findings. Transformational leadership is defined as one that stimulates awareness and interests in groups; fosters confidence of groups and individuals; and endeavors to drive the subordinate’s concerns about growth and achievements rather than mere existence (Gardner & Stough, 2002). Transformational leadership is measured with four sub-scales; namely: idealized influence, intellectual stimulation, inspirational motivation, and individualized consideration (Bass & Bass, 2009).

Research has found that transformational leadership style is more effective than the laissez-faire and transactional leadership styles (Gardner & Stough, 2002). Transformational leaders are consistently being rated as more effective by their subordinates and are always linked with superior organizational performance as well as success (Lowe, Kroeck, & Sivasubramaniam, 1996). In their study, Barling, Slater, and Kelloway (2000) examined the emotional intelligence and leadership styles of 49 managers. He found that emotional intelligence highly correlated with transformational leadership, with the highest correlation being among inspirational motivation (component of transformational leadership) and emotional intelligence (Barling et al., 2000). In 2002, a study by Gardner and Stough investigated whether emotional intelligence predicted the leadership styles of 110 senior level managers. They found a strong correlation between transformational leadership and overall emotional intelligence, with the components, understanding of emotions (external), and emotional management as the top predictors of transformational leadership style (Gardner & Stough, 2002).

Leban and Zulauf (2004) studied 24 project managers and their related projects in six different organizations from varying industries in order to examine the relationship between leadership in projects and emotional intelligence. They found that emotional intelligence scores and the ability to understand emotions were found in significant relation to inspirational motivation (a dimension of transformational leadership). They concluded that a project manager’s transformational leadership behavior has a positive impact on project performance, in other words, emotional intelligence abilities contribute to a project manager’s transformational leadership behavior and subsequent actual project performance (Leban & Zulauf, 2004). In addition, “transformational project management” can be accomplished by having results-focused project managers (via inspirational motivation, in other words, emotional intelligence) rather than those who are activity focused as in the case of transactional project managers (Leban & Zulauf, 2004). In another study, Butler and Chinowsky (2006) studied 130 construction executives to examine the relationship between emotional intelligence and transformational leadership behaviors. They concluded that a relationship existed between total emotional intelligence score (EQ) and transformational leadership behavior and that the total EQ explained 34% of the variance of transformational leadership.

Aga, Noorderhaven, and Vallejo (2016) reported that teambuilding as a critical project success factor plays a mediating role in the relationship between transformational leadership and project success. Thus, project-oriented organizations need to promote a transformational leadership style among project managers, for example, through selection and leadership development programs, which in sum, leads to the following hypothesis:

**H3**: Project managers’ transformational leadership has a significant positive effect on project success.

**Research Model**

After reviewing the relevant literature and to fulfill the objectives of the
Impact of Emotional Intelligence, Project Managers’ Competencies, and Transformational Leadership on Project Success

In the current study, the following research model (Figure 1) and hypotheses have been developed and tested in this study.

\[
\text{Project success} = \beta_0 + \beta_1 \text{EI} + \beta_2 \text{PMC} + \beta_3 \text{TL} + \epsilon
\]

Research Methodology

The nature of the research approach is quantitative in nature because it ensures the authenticity and reliability of the sample information selected for this research. A survey measure was employed to measure emotional intelligence, project managers’ competencies, transformational leadership, and project success in the construction industry in Pakistan.

Questionnaire Development

In this study, four variables, which includes three independent variables, are being studied; specifically, (1) emotional intelligence, (2) project managers’ competencies, and (3) transformational leadership; along with one dependent variable, in other words, project success. There were 62 questions in the questionnaire; however, 11 questions were removed after pilot testing, leaving 51 questions for the final survey. All questions were asked on a seven-point Likert Scale, ranging from strongly disagree to strongly agree. The net score of the items reflected the scores for the respective dimensions/construct.

Variables and Their Measures

Four variables were included in the study. The three independent variables included emotional intelligence, project managers’ competencies, and transformational leadership, with project success as the dependent variable.

Measure of Emotional Intelligence

For emotional intelligence, scales were adopted from the Goleman Emotional Competency Model (Goleman, 1998). Emotional intelligence has four dimensions; namely, (1) self-awareness, (2) self-management, (3) social awareness, and (4) relationship management. These were measured through 18 items on a seven-point Likert Scale, which ranged from strongly disagree to strongly agree. The net score of the items reflected the scores for the dimensions.

Measures of Project Managers’ Competencies

Project managers’ competencies was measured using Clarke’s (2010) scale, comprised of four dimensions: (1) communication, (2) teamwork, (3) attentiveness, and (4) managing conflicts. These were measured through 24 items on a seven-point Likert Scale, which ranged from strongly disagree to strongly agree. The net score of these items reflected the scores for the dimensions.

Measures of Transformational Leadership

To measure transformational leadership, scales developed by Clarke (2010) were adopted and they are: (1) idealized influence, (2) inspirational
motivation, (3) individual consideration, and (4) intellectual stimulation. These were measured (through four items) on a seven-point Likert Scale, which ranged from strongly disagree to strongly agree. The net score of the items reflected the score for the construct.

**Measures of Project Success**

For project success, the dimensions include being on time, being on budget, quality, and stakeholder satisfaction (Müller & Turner, 2010). It was measured through nine items on a seven-point Likert Scale, which ranged from strongly disagree to strongly agree. The net score of the items reflected the score for the construct.

**Population, Sample, and Sampling Technique**

For the present study, Pakistani construction firms were used as the target population. There were 325 construction companies registered with the Constructors Association of Pakistan (CAP) in 2016. The scopes of these companies range from the construction of residential and commercial buildings to large infrastructure projects. Through systematic random sampling, 107 companies (33%) were selected for data collection; in other words, every third company was selected for the data feedback by their respective managers at varying tiers through questionnaires. Four questionnaires were submitted to each company for manager feedback. Of the 428 questionnaires distributed, 359 responses (83.8% response rate) were received; of these, 14 responses (3.8% rejection rate) were rejected for incompleteness, whereas 345 responses (81.17% feedback rate) were completed in all respects, and were finally selected for this study. Table 1 highlights the demographic information of the respondents.

**Results and Discussions**

**Data Analysis Techniques**

The process of data analysis involved compilation of the data; its screening; descriptive statistics; and analysis of respondents’ demographics, assessing reliability measures, and running the correlation. Statistical Package for Social Sciences-20 (SPSS) software was employed. Hypotheses were tested using regression and correlation analysis.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>&gt;45 Years</td>
<td>120</td>
<td>34.78%</td>
</tr>
<tr>
<td></td>
<td>35–45 Years</td>
<td>158</td>
<td>45.80%</td>
</tr>
<tr>
<td></td>
<td>25–34 Years</td>
<td>67</td>
<td>19.42%</td>
</tr>
<tr>
<td>Educational background</td>
<td>PhD/Master’s degree</td>
<td>97</td>
<td>28.12%</td>
</tr>
<tr>
<td></td>
<td>Bachelor’s degree</td>
<td>189</td>
<td>54.78%</td>
</tr>
<tr>
<td></td>
<td>&lt;Bachelor’s degree</td>
<td>59</td>
<td>17.10%</td>
</tr>
<tr>
<td>Experience</td>
<td>&gt;15 Years</td>
<td>113</td>
<td>32.75%</td>
</tr>
<tr>
<td></td>
<td>10–15 Years</td>
<td>134</td>
<td>38.84%</td>
</tr>
<tr>
<td></td>
<td>5–10 Years</td>
<td>98</td>
<td>28.41%</td>
</tr>
<tr>
<td>Designation</td>
<td>Project director</td>
<td>44</td>
<td>12.75%</td>
</tr>
<tr>
<td></td>
<td>Project manager</td>
<td>103</td>
<td>29.86%</td>
</tr>
<tr>
<td></td>
<td>Functional manager</td>
<td>75</td>
<td>21.74%</td>
</tr>
<tr>
<td></td>
<td>Team leader</td>
<td>93</td>
<td>26.96%</td>
</tr>
<tr>
<td></td>
<td>Project sponsor–board member</td>
<td>30</td>
<td>8.69%</td>
</tr>
</tbody>
</table>

Table 1: Respondents’ demographics.

**Data Screening, Normality, and Reliability of the Data**

Prior to subjecting it to analysis, the data file was vigilantly screened for any missing values, outliers, multi-collinearity, and normality. The three basic options available for dealing with the missing data include: imputation, listwise deletion, and pairwise deletion (Tabachnick & Fidell, 2001). For this study, the first option (i.e., imputation) was resorted to in order to avoid loss of meaningful data or insufficient sample size. Missing values were very low (1 or 2) in most of the items. Moreover, none of the cases fell outside the limits (Q1 − 1.5 IQR, Q3 + 1.5 IQR), so there were no outliers within the data. Kurtosis and skewness were also performed to explain non-normality. Tabachnick and Fidell (2001) suggested their values to be within the range of −2 to 2, whereas the data are normally distributed.

Using principle components, exploratory factor analysis was conducted to test the construct validity of the variables. Factor analysis with Varimax rotation established the grouping of the emotional intelligence and project managers’ competency constructs. Items with correlations, between 4 and 8 within a group, and communalities, greater than 0.5, were retained, whereas Cronbach’s alpha (α) was used to measure the reliability of the constructs. Reliability of the measurement scales was checked and Cronbach’s alpha was found at a minimum of 0.7 for each separate construct. To assess the scale reliability, the most popular method is the internal consistency. For assessing the quality of scale, Churchill (1979) advocates the application of Cronbach’s alpha (α). Cronbach’s alpha (α) shows how well different items on the scale (that measure the similar constructs) yield the same results. Cronbach’s alpha (α) with a low score highlights the non-similarity of some of the items, which therefore must be deleted prior to proceeding further. No absolute guideline exists regarding an acceptable level of Cronbach’s alpha; however, for basic research, Nunnally and Bernstein
Impact of Emotional Intelligence, Project Managers’ Competencies, and Transformational Leadership on Project Success

(1994) suggested the reliability range of 0.5–0.6, whereas, Anderson and Gerbing (1988) suggested the value should be at 0.7 or above. The reliability analysis performed for this research remained at 0.7 and above. For this research, all the data were within acceptable ranges.

**Descriptive Statistics**

The descriptive statistics are provided in Table 2. Among emotional intelligence variables, ‘social awareness’ showed the highest consistency among the items (α = 0.931), demonstrating that it can be used as a single index. The mean score (M = 3.9, SD = 2.4) points out that, on average, project managers agree on managing conflicts through considering other points of views and attempting to build consensus toward conflict resolution. Past literature has also supported this point (MacIntosh & Stevens, 2008). Other managing conflict variables, namely, communication (α = 0.791, M = 4.47, SD = 1.04), teamwork (α = 0.894, M = 4.09, SD = 1.07), and attentiveness (α = 0.848, M = 4.2, SD = 1.12) have also shown acceptable reliability.

Furthermore, the transformational leadership variable (α = 0.890, M = 4.17, SD = 1.098) demonstrated acceptable reliability. The project success variable (α = 0.945, M = 4.15, SD = 0.671) has shown the highest consistency; hence, the resultant scales for all variables showed acceptable reliability, and items of respective scales can be averaged to calculate their composites. Moreover, kurtosis and skewness were also within range; therefore, the data are fairly normal.

**Construct Validity**

To test the construct validity of the variables in this study, exploratory factor analysis was carried out using principal components. Factor analysis with Varimax rotation determined the grouping of the emotional intelligence construct. Only variables with a factor loading greater than 0.5 were extracted (Hair, Anderson, & Black, 1995). Two factors were extracted with Eigenvalues greater than one; therefore, 18 items of the emotional intelligence construct were classified into four factors: self-awareness, self-management, social awareness, and relationship management. All factor loadings from 0.757 to 0.912 show a high level of internal consistency among emotional intelligence items. Similarly, factor analysis was employed to group 20 items of project managers’ competency constructs. The four factors categorized are communication, teamwork, attentiveness, and managing conflict. The factor loadings range from 0.735 to 0.910 (four items were not included because of low factor loadings and only 20 were included). Factor analysis was used to group 10 items of the transformational leadership construct. The four factors categorized are: idealized influence, inspirational motivation, intellectual stimulation, and individual consideration. The factor loadings could not load on dimensions, but four items loaded on the construct itself directly. Additionally, three factors that determine project success—the iron triangle, stakeholder satisfaction, and project scope—could not be loaded.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Cronbach’s α</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformational leadership</td>
<td>4.171</td>
<td>1.0999</td>
<td>−0.291</td>
<td>−0.176</td>
<td>0.890</td>
<td>4</td>
</tr>
<tr>
<td>Project success</td>
<td>4.157</td>
<td>0.67138</td>
<td>0.216</td>
<td>1.459</td>
<td>0.945</td>
<td>9</td>
</tr>
<tr>
<td><strong>Emotional intelligence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Self-management</td>
<td>4.1338</td>
<td>1.30296</td>
<td>−0.438</td>
<td>−0.511</td>
<td>0.817</td>
<td>3</td>
</tr>
<tr>
<td>Self-awareness</td>
<td>4.1128</td>
<td>1.21617</td>
<td>−0.148</td>
<td>−0.658</td>
<td>0.841</td>
<td>6</td>
</tr>
<tr>
<td>Social awareness</td>
<td>3.9757</td>
<td>1.40253</td>
<td>−0.040</td>
<td>−0.655</td>
<td>0.931</td>
<td>3</td>
</tr>
<tr>
<td>Relationship management</td>
<td>4.1546</td>
<td>1.02946</td>
<td>−0.279</td>
<td>0.581</td>
<td>0.892</td>
<td>6</td>
</tr>
<tr>
<td><strong>Project managers’ competencies</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Communication</td>
<td>4.4778</td>
<td>1.04910</td>
<td>−0.669</td>
<td>0.490</td>
<td>0.791</td>
<td>3</td>
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<tr>
<td>Team work</td>
<td>4.0924</td>
<td>1.07946</td>
<td>−0.761</td>
<td>0.800</td>
<td>0.894</td>
<td>5</td>
</tr>
<tr>
<td>Attentiveness</td>
<td>4.2477</td>
<td>1.12875</td>
<td>−0.350</td>
<td>−0.370</td>
<td>0.848</td>
<td>5</td>
</tr>
<tr>
<td>Managing conflict</td>
<td>4.2906</td>
<td>1.18521</td>
<td>−0.503</td>
<td>−0.372</td>
<td>0.915</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 2: Descriptive statistics.
and nine items loaded directly on the construct itself.

**Confirmatory Factor Analysis**

Confirmatory Factor Analysis (CFA) was employed to confirm the measurement model (Anderson & Gerbing, 1998). Data were analyzed using the SPSS statistical package. The model refinement was used to improve fit to recommended levels, as shown in the Appendix at the end of the article. By performing several trials, which excluded some items, all scales met the recommended levels. Furthermore, the composite reliability of all constructs was above the 0.7 level, as suggested by Hair et al. (2006), showing sufficient reliability for each construct.

All factor loadings were statistically significant at the 5% level and exceeded the 0.5 standard (Fornell & Larcker, 1981), as shown in the Appendix. These constructs demonstrate adequate convergent validity. Discriminant validity determines the constructs are measuring different concepts (Hair et al., 1998). As per the results indicated in the Appendix, the value of the KMO was well within range (in other words, between 0.5 and 1.0; hence, factor analysis stands appropriate (Malhotra, 2008). The factor analysis isn’t appropriate when the value of the KMO is below 0.5 (Malhotra, 2008). All the related items that measure the particular construct are loaded together with the value of factor loading above 0.5. Thus, it can be concluded that the measurement scales have a higher degree of convergent validity. The result of discriminant validity indicates that items were not cross loading, and supported respective constructs as whole items were allocated according to the different constructs.

**Correlation**

Table 4 shows the bivariate correlations among the observed variables. The project success, emotional intelligence, transformational leadership, and project managers’ competencies demonstrated positive weak to positive moderate relationships among them. Emotional intelligence measures

| Table 3: Fitness indicators of the CFA model. |
|-----------------|---------|---------|---------|---------|---------|---------|
|                | CMIN   | DF      | CMIN/DF | P-Value | TLI    | GFI    | CFI    | RMSEA  |
| Transformational leadership | 246.7  | 92      | 2.68    | 0.00    | 0.95   | 0.93   | 0.12   | 95.7   |

**Table 4: Bivariate correlations.**

<table>
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<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
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<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Transformational leadership</td>
<td>1.00</td>
<td>0.411**</td>
<td>1</td>
<td>0.071</td>
<td>0.193**</td>
<td>0.138*</td>
<td>0.192**</td>
<td>0.180**</td>
<td>0.245**</td>
<td>0.164**</td>
</tr>
<tr>
<td>2. Project success</td>
<td></td>
<td>1</td>
<td>0.031</td>
<td>1</td>
<td>0.514**</td>
<td>0.554**</td>
<td>0.501**</td>
<td>0.634**</td>
<td>0.403**</td>
<td>0.323**</td>
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<td>3. Self-management</td>
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<td>4. Self-awareness</td>
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<td>5. Social awareness</td>
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<td>6. Relationship management</td>
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<td>7. Communication</td>
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<td>8. Team work</td>
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<td>9. Attentiveness</td>
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<tr>
<td>10. Managers’ conflict</td>
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</table>

**. Correlation is significant at the 0.01 level.**

**. Correlation is significant at the 0.05 level.**

N = 345
showed a positively weak relationship with project success (0.031<\gamma<0.244**). All calculations were in the required levels and statistically significant (p < 0.05) except for the calculations between self-management and transformational leadership (\gamma = 0.071, p > 0.05); self-management and project success (\gamma = 0.031, p > 0.05); social awareness and project success (\gamma = 0.061, p > 0.05); self-management and communication (\gamma = 0.062, p > 0.05); communication and social awareness (\gamma = 0.014, p > 0.05); attentiveness and transformational leadership (\gamma = 0.019, p > 0.05); and attentiveness and social awareness (\gamma = 0.084, p > 0.05).

Moreover, all emotional intelligence measures (i.e., self-awareness and relationship management) are significantly correlated with project success (0.192<\gamma<0.244). Moreover, all project managers’ competency measures (i.e., communication, team work, attentiveness, and managing conflict) are significantly correlated with project success (0.199<\gamma<0.314). Finally, transformational leadership is significantly correlated with project success (\gamma = 0.411).

**Regression**
The adjusted R square (0.519) shows the fitness of the model (Table 5). The value shows that 51.9% of variations occur in the dependent variable (project success) due to the independent variables (emotional intelligence, project managers' competencies, and transformational leadership). Because of the multiple regression, the R square value cannot be useful. The remaining variation (49.1%) occurs due to the other factors. The F value shows (56.081) that hypotheses are accepted, because the T value is greater than 2 (H1: 5.141) (H2: 3.528) (H3: 5.755).

Project success = \beta_0 + 0.285EI + 0.192PMC + 0.27TL + €

Emotional intelligence was found to be significantly positively correlated with project success. Its beta value at 0.285 shows that one unit change in emotional intelligence has a 28.5% impact on project success; however, it is in line with the study by Clarke (2010). This study found that project managers who possess a positive attitude and optimism about success, remain attentive toward all stakeholders, and respond to the expectations and concerns raised by them, are more successful than their counterparts.

Transformational leadership was found to be positively correlated with project success. Its beta value is at 0.270, which is in line with all previous studies by Gardner and Stough (2002) and Avolio and Yammarino (2013). Trans-

---

### Model Summary

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Standard Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.675a</td>
<td>0.524</td>
<td>0.519</td>
<td>0.55181</td>
</tr>
</tbody>
</table>

*a. Predictors: (Constant), transformational leadership, project management competency, and emotional intelligence*

### ANOVA*

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>51.228</td>
<td>3</td>
<td>17.076</td>
<td>56.081</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>103.831</td>
<td>341</td>
<td>0.304</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>155.058</td>
<td>344</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*b. Predictors: (Constant), transformational leadership, project management competency, and emotional intelligence*

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Table 5: Model summary.
Transformational project managers provide vision and are a source of inspiration for coworkers, and articulate shared goals and mutual understanding of what is right and important for success of the project. They build trust among their colleagues and coworkers and thus promote an enthusiastic team ready to meet the project’s challenges.

Discussion of the Results
The primary objective of this research was to examine the roles of emotional intelligence, project managers’ competencies, and transformational leadership in improving project performance. The results showed significant positive relationships of three independent variables (emotional intelligence, project managers’ competencies, and transformational leadership) with a dependent variable (project success). These findings are shown in Table 5. The main results show that emotional intelligence, project managers’ competencies, and transformational leadership have positive impacts on project success. The reason behind this positive stream is the training and development opportunities in the field of project management in recent years in Pakistan, specifically the number of Project Management Professional (PMP)® certification holders, which has been increasing every year. Along with technical expertise, construction firms are taking project managers’ soft skills more into consideration.

Emotional intelligence was found to be significantly positively correlated with project success. Its beta value at 0.285 shows that one unit change in emotional intelligence has a 28.5% impact on project success, which means Hypothesis 1 (H1) is accepted. This is in line with the previous studies of Mount (2006) and Geoghegan and Dulewicz (2008). According to Goleman (1998), emotional intelligence contributes positively to individual and organizational success. The results show that although in the Pakistani construction industry, the concept of emotional intelligence appears to not yet be fully realized, the fact remains that it has been employed effectively. During interviews with construction executives during the pilot study, it was apparent this concept was new to them yet they admitted to using those competencies. This calls for a need to impart necessary training in the emotional intelligence domain.

The results showed that the emotional intelligence measures of self-awareness and relationship management, are highly significantly correlated with project success (0.192<γ<0.244); in other words, project managers who possess self-awareness (emotional intelligence dimension) are also excellent at relationship management (emotional intelligence dimension); as a result, they build an effective team based on teamwork, collaboration, inspirational leadership, and leading from the front. This ultimately transcends into contributing dividends to project success. Winter, Smith, Morris, and Cicmil (2006) suggested that emotional intelligence is associated with the intuition and skills required for project managers to develop into reflective practitioners. As a result, project managers with high emotional intelligence would be better prepared to resolve the new challenges and problems that each new project brings (Davis, 2011).

Project managers’ competencies were found to be significantly positively correlated with project success. The beta value of 0.192 shows that one unit change in project managers’ competencies has a 19.2% impact on project success. So Hypothesis 2 (H2) is also accepted. This is in line with the study by Clarke (2010) who found that project managers’ competency measures (i.e., communication, team work, attentiveness, and managing conflict) have positive impacts on project success. This study states that project managers with a positive attitude and optimism for success, who remain attentive to all stakeholders, and respond to the expectations and concerns raised by them, are more successful than their counterparts (Khan, Long, & Iqbal, 2014; Butler & Chinowsky, 2006). According to Zhang et al. (2013), project managers with a range of core competencies are critical to the success of projects.

Finally, transformational leadership was also found to be significantly correlated with project success (γ = 0.411), which is in line with the previous studies of Clarke (2010), Leban and Zulauf (2004), and Avolio and Yammarino (2013). The results from this study demonstrate that high levels of project manager transformational leadership positively affect project performance, which explains 27% of the variance in project performance. Transformational project managers are a source of inspiration for coworkers; they provide vision and articulate shared goals and mutual understanding of what is right and important for the success of project (Yang et al., 2011). They also build trust among their colleagues and coworkers and thus promote an enthusiastic team ready to meet the project challenges (Müller & Turner, 2010). According to Pieterse, Knippenberg, Schippers, and Stam (2010, p. 610), “transformational leadership is an approach to leading that changes followers, causing them to look beyond self-interest in favour of the group’s objectives by modifying their morale, ideals and values.” In addition, it is associated with stimulating and inspiring followers to deliver extraordinary results while developing their own leadership abilities (Bass & Riggio, 2006). Moreover, the high performance expectation behavior of the transformational leader is reflected in the leader’s expressed belief in the ability of the followers to deliver excellence and high quality performance (Kissi, Dainty, & Tuuli, 2013).

Hypothesis H1: ‘Emotional intelligence has a significant effect on project success’ is accepted. Managers who are emotionally self-aware can manage their emotions better than others and,
therefore, are more socially aware and are good at managing the emotions of others (Goleman, 2003). Such managers are good leaders and are emphatic toward others and organizational concerns (Müller & Turner, 2010). Such leading managers drive their team members toward individual and project/organizational success (Goleman et al., 2013).

Hypothesis H2: ‘Project managers’ competencies have a significant positive effect on project success’ is accepted. Managers who remain in direct communication with their employees remain attentive to their concerns and therefore are always good at managing conflicts before they occur (Clarke, 2010). Such leaders promote teamwork among their employees with themselves acting as the mentor—together these competencies make them the primary influencers, thus achieving collective successes.

Hypothesis H3: ‘Project managers’ transformational leadership has a significant positive effect on project success’ is also accepted. Transformational leadership is more open to communication and is consistently being rated as more effective by subordinates and is always linked to superior organizational performance as well as success (Lowe et al., 1996). Pinto, Thoms, Trailer, Palmer, and Govekar (1998) suggested that transformational leadership is relevant in the project-based environment as it enables managers to transform their project teams and ultimately impacts project performance. A leader knows and satisfies his or her people’s needs, understands what drives people, and promotes their interests while pursuing the project’s objectives (Barling et al., 2000). He or she continuously encourages promotion of intellectual thinking among his or her followers (Feger & Thomas, 2012); as a result, he or she leaves an idealized influence on his or her followers who in turn follow him or her (Müller & Turner, 2010).

**Findings, Implications, Limitations, and Conclusion of the Study**

**Theoretical Findings**

The findings lead to reporting a strong understanding about the association of emotional intelligence, project managers’ competencies, and transformational leadership style with the success of the project. Construction project managers with a high emotional quotient, bestowed with transformational leadership behavior, and blessed with competencies such as communication skills, team work, attentiveness toward others, and conflict management skills, are expected to contribute more to the success of projects than their counterparts. However, this does not undermine the importance of hardcore managerial skills and cognitive intelligence (IQ) among construction project managers, which remain of equal significance. The study suggests that project managers with a high emotional quotient, transformational leadership, and added competencies will have the added advantages of better performance and success over those lacking them. In other words, the three independent variables in this study—namely, emotional intelligence, project managers’ competencies, and transformational leadership—can be termed as indicators of enhanced performance by construction project managers in addition to hardcore managerial skills and cognitive abilities. Success, not only in projects but the organization itself can be multiplied manifold through emotionally intelligent project managers who possess the required competencies and exhibit transformational leadership behavior.

**Practical Implications of the Study**

In this study, we have examined the impact of emotional intelligence, project managers’ competencies, and transformational leadership on project success. The results imply that Pakistani construction firms must look to hire the emotionally intelligent managers, along with looking for cognitive intelligence and expertise in hardcore managerial skills. Moreover, the existing workforce must also be trained to enhance their emotional intelligence through undergoing professional courses. As a result, the emotionally intelligent workplace will prevail and will contribute better toward mutual and organizational success. The study also suggests that construction companies must seek managers who are more transformational leaders and able to lead their teams well. Furthermore, firms must enlist four top competencies for hiring the project managers, which includes effective communication, conflict management, teamwork, and attentiveness. The findings also suggest that organizations should strive to train their existing workforce in emotional intelligence and desired competencies in order to ensure organizational success.

**Limitations and Avenues for Future Research**

Although this study was conducted in one country due to the limitations of resources and time, its findings can be generalized to those areas where socio-economic conditions are similar to those in Pakistan. The same model can also be used in other countries and in international settings to measure the accurate relationships between project managers’ soft skills and project success. In future studies, it may be beneficial to integrate cultural practices in the model, (for example, as moderators in relationships between project managers’ soft skills and project success). We cannot expect the results in different industrial projects to be the same as those in construction projects. One might argue that project managers maybe more effective in more competitive and supportive work environments. Nevertheless, we recommend future research to develop across industrial studies in order to investigate better comparative and authentic outcomes. Future studies can also continue...
to examine the deeper mechanisms and enrich their implications through longitudinal research.

Conclusion
In this study we examined the relationships and impacts of emotional intelligence, project managers’ competencies, and transformational leadership style vis-a-vis project success. This study empirically supported the hypotheses that emotional intelligence, project managers’ competencies, and their transformational leadership styles have direct positive impacts on project success.

Consistent with the theoretical argument, this study provides support to the hypothesis that emotionally intelligent project managers perform better than their counterparts, as they not only understand their own emotions but those of others, and manage their own and others’ emotions in the appropriate way. This creates an aura of friendliness and trust that ultimately benefits the organization through successful completion of assigned tasks. The construction industry is characterized by a diversified workforce and enormous time, budget, and resource challenges, which require project managers to be more interactive with all employees and stakeholders. Emotionally intelligent construction managers can better manage the emotions of themselves as well as others involved in the project, which paves the way to a friendly environment among all project stakeholders and further contributes to the added efficiency of the project.

Consistent with the theoretical arguments, this study also provides support for the hypothesis that construction project managers with competencies such as open communication, teamwork, attentiveness toward others, and conflict management, perform exceptionally well. In the construction industry, projects are more likely to experience delays due to issues pertaining to resource management, availability of the required workforce, availability of supplies, and so forth. Efficient and better performing project managers forestall these project delays through efficient communication with all project stakeholders, attentiveness to project needs, exemplary teamwork through effective team building, and an effective conflict management approach that addresses issues in a timely and amicable way. This results in a positive impact on project success.

This study also offers support for the hypothesis that project managers exercising transformational leadership styles are better performers and thus contribute to project success. Transformational leaders are inspirational: they lead their teams; inspire their employees; stimulate awareness and interests; foster confidence; and endeavor to drive their teams’ concerns, growth, and achievements. This builds a friendly project environment, in which the entire workforce works as a team under the trustworthy leadership of a project manager toward the attainment of common objectives. The arguments presented here suggest the following conclusions: (1) emotional intelligence has a direct positive impact on the success of projects, (2) project managers’ competencies have direct impacts on project success, and (3) project managers’ transformational leadership behavior has a direct positive impact on project success. Thus, the success of a project isn’t just all about state-of-the-art equipment or the latest inventions, but it is also about people and their behaviors as well as competencies, which are the main driving forces behind success.

This study will not only fill the literary gap as already discussed earlier, it will also help Pakistani project managers weigh project performance from a different perspective, which is something that hasn’t been touched upon hitherto. The study will contribute to widening the existing knowledge base for project performance by adding to the findings regarding the impact of emotional intelligence, project managers’ competencies, and transformational leadership behavior on project success. It will also serve as a basic guideline document for senior management in the Pakistani construction industry, which will assist them in hiring project managers with a greater emotional quotient (EQ) and also train their existing managers (project and line managers) in developing and exercising emotional intelligence, competencies, and transformational leadership behavior with an overall aim to achieving organizational excellence. This study will also pave the way for new directions for future researchers in carrying out the study on a global level with a view to finding concrete recommendations for ensuring project performance at the upper, middle, and lower levels of management.

Acknowledgments
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Impact of Emotional Intelligence, Project Managers’ Competencies, and Transformational Leadership on Project Success


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### Appendix

**Research Questionnaire**

*Factor Analysis through Principle Component Analysis*

<table>
<thead>
<tr>
<th>No.</th>
<th>Variable Items</th>
<th>Factor Loading</th>
<th>% of Variance Explained</th>
<th>EigenValue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Self-Awareness</strong> (refers to knowing your internal states, preferences, resources, and intuitions)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 I recognize my own emotions and their effects.</td>
<td>0.815</td>
<td>85.85</td>
<td>2.576</td>
</tr>
<tr>
<td></td>
<td>2 I know my strengths and weaknesses.</td>
<td>0.828</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 I have a strong sense of self-worth and capabilities.</td>
<td>0.838</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Self-Management</strong> (refers to managing your internal states, impulses, and resources)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 I keep disruptive emotions and impulses in check.</td>
<td>0.820</td>
<td>77.4</td>
<td>4.46</td>
</tr>
<tr>
<td></td>
<td>2 I maintain integrity and act congruently with my values.</td>
<td>0.805</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 I am persistent in pursuing my goals despite obstacles and setbacks.</td>
<td>0.754</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 I exercise flexibility in handling change.</td>
<td>0.794</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 I strive for improvement or meeting a standard of excellence.</td>
<td>0.774</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 I am always ready to act on opportunities.</td>
<td>0.790</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Social Awareness</strong> (refers to how you handle relationships and awareness of others’ feelings, needs, and concerns)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 I sense others’ feelings and perspectives and take an active interest in their concerns.</td>
<td>0.870</td>
<td>87.9</td>
<td>2.64</td>
</tr>
<tr>
<td></td>
<td>2 I read/understand my group’s emotional currents and power relationships.</td>
<td>0.888</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 I anticipate, recognize, and meet my customers’ needs.</td>
<td>0.855</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Relationship Management</strong> (concerns the skill or adeptness at inducing desirable responses in others)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 I sense others’ developmental needs and bolster their abilities.</td>
<td>0.706</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 I inspire and guide individuals and groups.</td>
<td>0.780</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 I use effective tactics for persuasion.</td>
<td>0.851</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 I initiate or manage change.</td>
<td>0.785</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 I negotiate and resolve disagreements.</td>
<td>0.762</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 I work with others toward shared goals and create group synergy in pursuing collective goals.</td>
<td>0.734</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Impact of Emotional Intelligence, Project Managers’ Competencies, and Transformational Leadership on Project Success

**Project Managers’ Competencies.** Competencies are the learned capabilities based on emotional intelligence that results in outstanding performance at work.

<table>
<thead>
<tr>
<th>Communication</th>
<th>Score</th>
<th>%</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I understand the communication from others involved in the project.</td>
<td>0.621</td>
<td>70.95</td>
<td>2.13</td>
</tr>
<tr>
<td>2 I maintain a formal communication channel.</td>
<td>0.727</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 I maintain an informal communication channel.</td>
<td>0.760</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Team Work</th>
<th>Score</th>
<th>%</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I encourage teamwork consistently.</td>
<td>0.693</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 I share my knowledge and expertise with others involved in the project.</td>
<td>0.851</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 I maintain good working relationships with others involved in the project.</td>
<td>0.586</td>
<td>70.66</td>
<td>3.53</td>
</tr>
<tr>
<td>4 I build trust and confidence with both stakeholders and others involved on the project.</td>
<td>0.820</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 I help to create an environment of openness and consideration on the project.</td>
<td>0.600</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attentiveness</th>
<th>Score</th>
<th>%</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I respond to and act on expectations, concerns, and issues raised by others on the project.</td>
<td>0.776</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 I actively listen to other project team members or stakeholders involved in the project.</td>
<td>0.786</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 I express positive expectations of others involved in the project.</td>
<td>0.624</td>
<td>69.15</td>
<td>2.77</td>
</tr>
<tr>
<td>4 I help to build a positive attitude and optimism for success in the project.</td>
<td>0.618</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 I successfully engage all stakeholders involved in the project.</td>
<td>0.680</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Managing Conflict</th>
<th>Score</th>
<th>%</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I help others to see different points of view or perspectives.</td>
<td>0.764</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 I recognize conflict within an early timeframe.</td>
<td>0.691</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 I resolve conflict amicably.</td>
<td>0.821</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 I work effectively with the organizational politics associated with the project.</td>
<td>0.695</td>
<td>74.68</td>
<td>5.97</td>
</tr>
<tr>
<td>5 I attempt to build consensus in the best interests of the project.</td>
<td>0.782</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 I manage ambiguous situations satisfactorily while supporting the project’s goal.</td>
<td>0.758</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 I maintain self-control and respond calmly and appropriately in all situations.</td>
<td>0.832</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Transformational Leadership. Transformational leadership is defined as one that stimulates awareness and interests in groups, fosters confidence in groups and individuals, and endeavors to drive the concerns of subordinates toward growth and achievements rather than mere existence.

<table>
<thead>
<tr>
<th></th>
<th>As leader, I deal with my employees with integrity and appeal to them emotionally.</th>
<th>0.756</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>I am able to build trust and a shared sense of vision in my team members.</td>
<td>0.716</td>
</tr>
<tr>
<td>3</td>
<td>I help employees learn tackling and solving problems on their own.</td>
<td>0.781</td>
</tr>
<tr>
<td>4</td>
<td>As leader, I inspire and motivate my employees to work optimistically toward challenging goals.</td>
<td>0.758</td>
</tr>
</tbody>
</table>

Project Success. A project is successful if it has fulfilled its scope while remaining within the budgeted cost, scheduled timeframe and desired quality while ensuring satisfaction of all stakeholders.

<table>
<thead>
<tr>
<th></th>
<th>I completed my projects on time as scheduled.</th>
<th>0.634</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>I completed my projects within the allocated budget.</td>
<td>0.770</td>
</tr>
<tr>
<td>3</td>
<td>In the project, I met the quality needs and requirements of the customers.</td>
<td>0.663</td>
</tr>
<tr>
<td>4</td>
<td>I was able to achieve satisfaction of my team members with overall project management and performance.</td>
<td>0.731</td>
</tr>
<tr>
<td>5</td>
<td>I was able to manage and satisfy all project stakeholders with the project deliverables/outcome.</td>
<td>0.728</td>
</tr>
<tr>
<td>6</td>
<td>I was able to achieve end users’ satisfaction with the project outcome/deliverables.</td>
<td>0.670</td>
</tr>
<tr>
<td>7</td>
<td>I was able to ensure satisfaction of suppliers involved in the project.</td>
<td>0.703</td>
</tr>
<tr>
<td>8</td>
<td>I was able to achieve the project’s purpose.</td>
<td>0.629</td>
</tr>
<tr>
<td>9</td>
<td>I am confident that my projects have achieved their self-defined criteria of success.</td>
<td>0.768</td>
</tr>
</tbody>
</table>

Note: KMO Measure of Sampling Adequacy = 0.81
Ex Post Risk Management in Public-Private Partnership Infrastructure Projects

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INTRODUCTION

In the traditional procurement model, public infrastructure is delivered by the public sector. Public-private partnerships (PPPs) provide an innovative procurement model to deliver public infrastructure by the private sector through contractual relationships between the public and private sectors. The public partner, hereinafter referred to as the government, has needs for new infrastructure, and then grants a concession to the private sector, hereinafter referred to as the contractor, to finance, design, build, and operate an infrastructure project (Zhang, 2009). The government supervises and regulates the concession through contracts and regulations. Meanwhile, the contractor provides relevant services/products according to the specifications and receives payments from the end users or the government itself. At the end of the concession, the contractor transfers the concession and the project assets to the government. This type of contract arrangement has been widely applied to infrastructure projects around the world since the mid-1980s (Carpintero & Petersen, 2015; Shen, Li, & Li, 2002).

Today, infrastructure investments depend heavily upon private capital markets for financing and on private firms for managerial expertise (Marques & Berg, 2011). However, project financing is more risky than traditional corporate financing in delivering infrastructure projects. One reason is that the leverage level of project financing is usually much higher than that of corporate financing. The equity invested by contractors is their long-term commitment to project lenders, and the higher it is, the lower the risk level is. However, for most PPP infrastructure projects, the debt ratio is higher than 50% (Pantelias & Zhang, 2010). For example, power projects tend to have a debt level of 70% to 90% (Zhang, 2005). In addition, contractors in PPP infrastructure projects are required to take more risks than those in traditional projects because governments transfer some risks to them (Hwang, Zhao, & Gay, 2013). Transferring risks to the private sector in PPP infrastructure projects has been one of the main objectives of governments (Yuan, Skibniewski, Li, & Zheng, 2010). Therefore, contractors in PPP infrastructure projects are likely to be exposed to excessive risks that are not within their expertise to master, or out of their capability to undertake.

Excessive risks could cause serious risk scenarios in PPP infrastructure projects. In the bidding documents, an inappropriate or excess transfer of risk to contractors might reduce the number of bidders and foster opportunism of the remaining tenderers (Zitron, 2006). One of the most popular opportunistic behaviors is that the contractor wins the bid with a low price and then forces favorable renegotiations after the contract has been signed. In the concession

ABSTRACT

Public-private partnerships (PPPs) have been widely used in infrastructure development in the past 30 years. However, a number of PPP projects have suffered serious risk scenarios and ended up with project failures. The change from a short-term contract period of traditional projects (fewer than five years) to a long-term contract period of PPP projects (20–30 years) has raised challenges to the traditional risk management. The high occurrence of renegotiations and early terminations of PPP projects suggest that ex ante risk management is no longer enough and ex post risk management is needed. This study aims to propose an ex post risk management model, under which renegotiations and early terminations are introduced. The application of this model begins with risk impact evaluation, then ex post risk response measures assessment, selection, and enforcement. An illustrative case is provided in the Appendix at the end of the article. The outputs of this study would facilitate governments’ decision making in PPP projects under serious risk scenarios.

KEYWORDS: public-private partnerships; risk management; renegotiation; early termination

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agreements, flawed risk allocation can raise the costs of infrastructure services (Akintoye, Hardcastle, Beck, Chinyio, & Asenova, 2003; Zhu, Zhao, & Chua, 2016), or even lead to contract failure, renegotiation, and/or early termination (Marques & Berg, 2011). Guasch (2004) examined approximately 1,000 Latin American concession contracts, and found that 53% of those in the transport sector and 76% of those in the water sector were renegotiated. In addition, Xiong, Zhang, and Chen (2015) found that 334 out of 4,874 PPP projects (6.85%) in developing countries were terminated early.

Serious risk scenarios, such as renegotiations and early terminations, are usually out of the capacity of practitioners in PPP projects, because traditional risk management focuses on dealing with risks in an ex ante way. The change from a short-term contract period of traditional projects (fewer than five years) to a long-term contract period of PPP projects (20–30 years) has raised challenges to the traditional risk management. In a short-term project, it is possible to identify and evaluate the majority of risks and prespecify their allocation strategies and mitigation measures in the contract. However, in a long-term project, it is impossible or too expensive to do so. Therefore, it is necessary to shift the ex ante risk management to a trade-off between the ex ante and the ex post way in PPP projects.

This study attempts to develop an ex post risk management mechanism for serious risk scenarios in PPP infrastructure projects. First, a framework for ex post risk management is proposed based on a literature review. Then, an ex post risk management model is developed based on the financial equilibrium of PPP infrastructure projects. After that, selection criteria of the ex post risk response measures are set according to their effectiveness and characteristics. An illustrative case is applied to demonstrate the applicability of the proposed ex post risk management model. Finally, conclusions and recommendations are presented.

### Background

#### Risks in PPP Infrastructure Projects

Risk is the probability of the occurrence of a harmful event (Hwang, Zhao, Yi, & Zhong, 2015; Parker & Handmer, 2013). Many scholars have studied the risks in PPP infrastructure projects. Some scholars identified significant risk factors in different countries. For instance, Ke, Wang, Chan, and Lam (2010); Roumboutsos and Anagnostopoulos (2008); and Chung, Hensher, and Rose (2010) investigated the risks of PPP infrastructure projects in China, Greece, and Australia, respectively. Based on previous studies, Chan, Yeung, Yu, Wang, and Ke (2011) provided a comprehensive identification of risks in PPP projects, as shown in Table 1. It contains two major categories: systematic risks and specific project risks, as well as more than 30 risk factors.

PPP infrastructure projects are usually vulnerable to risks due to several reasons. First, PPP contracts are too complicated and incomplete, and thus it is impossible to cover all the risks in the clauses (De Brux, 2010). In addition, many risks in PPP infrastructure projects are very difficult to be precisely assessed due to large project scales and long durations. For instance, underestimation of demand shortfall is quite normal in traffic projects (Cruz & Marques, 2013b). Moreover, stakeholders could overestimate their capability of taking risks. The risk appetite of the project manager determines the risk transfer from the government (Kwak & LaPlace, 2005). Nevertheless, the project manager could make mistakes in the perception of the project’s risk capacity due to the reasons of unprofessional decision making, inadequate information, excessive risk-taking actions, and so forth. Therefore, it is not surprising that many PPP infrastructure projects have experienced serious risk scenarios in the past 30 years.

#### Risk Tolerances of Stakeholders

Risk tolerance refers to the capacity to withstand the effects of a risk, in other words, risk tolerance in terms of severity is the point above which a risk is
not acceptable and below which the risk is acceptable (Newell & Grashina, 2004). Sometimes, risk tolerance is also regarded as a risk threshold or contract contingency (Project Management Institute, 2000). In PPP infrastructure projects, the main stakeholders are the contractors, the government, and the general public (Yuan et al., 2010). They share the risks according to their risk preferences, thus having different risk tolerances. Generally speaking, contractors focus on commercial risk tolerances, which are basically defined in the financial base case in terms of several financial indicators. Cruz and Marques (2013b) studied quantitative indicators to initiate renegotiation in Portuguese concession contracts, such as the impact of particular events measured by decreases of 0.03% on one of the following ratios: debt service coverage ratio (DSCR), loan life coverage ratio (LLCR), and shareholder’s internal rate of return (IRR). These indicators are the commercial risk tolerances of a contractor. Similarly, other financial indicators, such as minimum revenue, minimum rate of return for equity, minimum traffic demand, least-present-value-of-revenue (LPVR), and least-present-value-of-net-revenue (LPVNR), can also serve as the commercial risk tolerances of a contractor.

Governments also have commercial risk tolerances, which are mainly the investment requirements committed by the contractor in the agreement. Delay or reduction in investment may initiate government-led renegotiation or early termination. However, governments should concentrate on the production risk tolerances since their main objective is to maximize the social benefits of projects. The production risk tolerance is usually indicated by a set of performance indicators in the specification, incorporating the tolerance of the failure probability for each item. According to Guasch (2004), renegotiation is more likely to occur in contracts with investment requirements (70%) than those with performance indicators (18%).

With regard to the general public, the commercial risk tolerance is mainly the toll rate tolerance; the production risk tolerance tends to include the environment pollution tolerance, the public facilities quantity tolerance, and the public services quality tolerance. In the past PPP experience, the general public’s tolerances were more likely to be neglected. Therefore, many PPP infrastructure projects experienced serious risk scenarios caused by the general public. For instance, the high toll levels and traffic congestion on surface streets caused the community rejection of the Cross City Tunnel in Sydney (Chung et al., 2010); the pollution and damage to the marine environment caused a public protestation that suspended the construction of the Hong Kong-Zhuhai-Macao Bridge for five months. Hence, practitioners have focused on the general public’s risk tolerances.

**Serious Risk Scenarios**

Serious risk scenarios are defined as situations when the risk impacts of risks exceed the risk tolerance of the stakeholders of PPP infrastructure projects. In this study, there are two determinants for serious risk scenarios: driving risks and risk tolerances. Among all the risks listed in Table 1, most risks are supposed to be tackled appropriately through risk management, and only a minority of them could be out of control and drive PPP infrastructure projects into serious risk scenarios. The driving risks could act individually or jointly. Cruz and Marques (2013a) indicated that the most popular driving risks of serious risk scenarios were demand shortfall, construction cost overrun, operation and maintenance (O&M) cost overrun, and public rejection of toll rate. In addition, serious risk scenarios in PPP infrastructure projects can occur to all the main stakeholders because all of them have risk tolerances. Any break of commercial risk tolerances or production risk tolerances makes the stakeholder claim for serious risk scenarios and forces favorable changes. For example, the private sector and the government can initiate renegotiations and early terminations, while the general public can protest to the government and force them to fight for the public interests.

**Ex Ante and Ex Post Risk Management**

Risk management in PPP projects should include both *ex ante* and *ex post* risk management. *Ex ante* here means the period before the signature of project agreement, whereas *ex post* means after this. This expression is extensively used in economics, especially in contract theory literature (Aghion & Bolton, 1992; Hart & Moore, 1988; Tirole, 1988). Generally speaking, if a contract is treated as a complete contract, risk management can be seen as solely *ex ante*. This is because, according to the complete contract theory, all contingencies can be forecasted and specified in contacts (Aghion & Holden, 2011). But if a contract is regarded as incomplete, risk management should involve the concept of *ex post* risk management. This is because according to the incomplete contract theory, it is impossible to resolve all risks in an *ex ante* way and those unresolved risks should be handled by *ex post* risk management. Some risks should be left unsolved deliberately and referred to *ex post* adjustments because it is too expensive to forecast and prespecify them in an *ex ante* way. It has been well-accepted that PPP agreements are typically incomplete contracts due to their long-term span, large scale, and complex nature (Hart, 2003; Hart, Shleifer, & Vishny, 1997; Iossa & Martimort, 2016).

Previous studies have investigated the *ex ante* risk management of PPP infrastructure projects, focusing on risk identification (Xu, Yang, Chan, Yeung, & Cheng, 2011), risk evaluation (Xu, Yeung, Chan, Chan, Wang, & Ke, 2010; Xu, Lu, Chan, Skibniewski, & Yeung, 2012), risk allocation (Cao & Zhang, 2008; Hwang et al., 2013; Jin, 2010; Ke, Wang, & Chan, 2010; Li, Akintoye, Edwards, & Hardcastle, 2005; Medda, 2007), financial risk (Pantelias & Zhang, 2010; Wibowo & Kochendörfer, 2005; Zhang, 2005), and political risk (Deng, Low, & Zhao, 2014;
However, few studies have focused on the ex post risk management in PPP infrastructure projects. Thus, this study can contribute to the literature through developing a quantitative ex post risk management model.

A general ex ante risk management process was developed by the Project Management Institute (2000), as shown in Figure 1. This process consists of risk management planning, risk identification, qualitative and quantitative risk evaluation, risk response, and risk monitoring and control. Compared with ex ante risk management, ex post risk management takes place after serious risk scenarios occur. In the discipline of public management, ex post risk management is usually referred to as “hazard management” (Parker & Handmer, 2013). The terms “hazard” and “risk” are often used interchangeably. However, “hazard” is usually an ever-present condition that leads to a harmful event, whereas risk can be seen as the probability that the exposure to a hazard will lead to a negative consequence (i.e., Risk = Hazard × Exposure) (Ropeik & Gray, 2002). After serious risk scenarios occur, the exposure is actually known. Therefore, the ex post risk management can follow the practice of hazard management. While hazard management normally focuses on natural disasters, ex post risk management mainly tackles man-made accidents in PPP infrastructure projects.

Hazard management comprises a series of stages including the evaluation of hazard impact; the evaluation, selection, and implementation of hazard reduction measures; and the establishment of enforcement procedures (Parker & Handmer, 2013). Similarly, the general ex post risk management process, as illustrated in Figure 1, includes risk impact evaluation, serious risk scenarios justification, ex post risk response, and renegotiation/early termination enforcement. After risks occur, risk impact evaluation is used to summarize the losses of affected stakeholders. If the risk impact is under risk tolerances, the affected party is supposed to retain the risks and no ex post risk response measures will be taken. However, if either the commercial or the production risk tolerance is exceeded, the affected party would take the ex post risk response measures to avoid further losses.

The ex post risk response is also called risk reallocation, which allows the excessive risk impacts to be distributed among the stakeholders. With respect to risk response strategies, risk mitigation focuses on prevention, and risk retention takes no measure. Therefore, available ex post risk response strategies are risk avoidance and risk transfer. The ex post risk response measures can be categorized into two groups: (1) renegotiations, where the affected party is compensated and the risks are transferred to other parties through substantial change in tariffs (standard, scheduled tariff adjustments excluded), investment plans and levels, exclusivity rights, guarantees, lump-sum payments or annual fees, coverage tar-

![Figure 1: Ex ante and ex post risk management for PPP projects.](image-url)
Developing a Quantitative Ex Post Risk Management Model

Confronted with serious risk scenarios, the government can use concession renegotiation to bail out the project and enable the private sector to finish the concession, or use early termination to buy out the project and finish the concession. In both strategies, the government has to pay compensation to the private sector (HM Treasury, 2007). Thus, the objective function of the ex post risk management approach is structured based on the financial equilibrium.

**Objective Function**
The financial equilibrium is one of the most important underlying principles of PPP infrastructure projects. Generally, the financial equilibrium of a concession means that revenues minus costs in the whole concession should provide a reasonable rate of return on capital investment. This principle has been well-acknowledged in previous PPP studies, and many simplified financial equilibrium equations were proposed for developing objective functions. For instance, based on financial equilibrium, Shen et al. (2002) and Wu, Chau, Shen, and Shen (2012) developed concession models; Pantelias and Zhang (2010) evaluated financial viability; and Guasch (2004) proposed a renegotiation model. In order to develop the objective function of this study, a tariff-based project is assumed to be procured through a PPP model with a fixed concession period, and its financial equilibrium is proposed as Equation (1).

\[
\sum_{t=t_0}^T d_t \lambda_t \left[ (P_t Q_t - OC_t - FC_t - DC_t) (1 - T) + S | - r I \right] \quad \text{Equation (1)}
\]

where \(t_0\) is the construction period; \(L\) is the concession length; \(d_t = (1 + r')^{-t}\); \(r'\) is the discount rate; \(\lambda_t\) is the currency exchange rate; \(P_t\) is the toll rate; \(Q_t\) is the annual demand; \(OC_t\) is the O&M cost in the concession period; \(FC_t\) is the financial cost, including interest of debts from different sources; \(DC_t\) is the depreciation of the construction cost; \(T\) is the tax rate; \(S\) is the annual subsidy or unitary payment from the government; \(r\) is the reasonable rate of return; and \(I\) is the capital investment. The data of these variables are usually available in the annual financial reports of PPP infrastructure projects.

**Risk Impact Evaluation**

In serious risk scenarios, excessive risk impact could break the financial equilibrium and cause a shortfall of profit from the expected level. Thus, the gap is defined as Equations (2) and (3).

\[
\Psi(X) = M(X) + \sum_{t=t_0}^T d_t \lambda_t \left[ (P_t Q_t - OC_t - FC_t - DC_t) (1 - T) + S | - r I \right] \quad \text{Equation (2)}
\]

\[
M(X) = \sum_{t=t_0}^T d_t \lambda_t \left[ (P_t Q_t - OC_t - FC_t - DC_t) (1 - T) + S \right] \quad \text{Equation (3)}
\]

where, \(\Psi(X)\) is the financial impact of hazards; \(X = \{x_1, x_2, \ldots, x_l\}\) is the vector of driving risks in hazards; \(t_1\) is the year when hazards occur; \(M(X)\) is the actual profit in the past concession with the impacts of \(X\); and \(M(X)\) is constant at \(t_1\).

**Ex Post Risk Response**

To reduce the impact of serious risk scenarios, the government has to resume the delivery of public facilities and service as soon as possible through either concession renegotiation or early termination. However, as discussed earlier, the private sector is willing to continue operation or sell the project to the government only if the deal provides a reasonable rate of return. The reasonable rate of return is usually between a guaranteed minimum rate of return and an expected rate of return. If a minimum rate of return has been guaranteed in an agreement, the reasonable rate of return can be the minimum rate of return and compensation will be made automatically to prevent project bankruptcy or bailout of the project; if not, the reasonable rate of return depends on an expected rate of return, which can be evaluated by the weighted-average-cost-of-capital (WACC) formula as Equation (4).

\[
r = \frac{WACC}{D + E} + k_D (1 - T) \quad \text{Equation (4)}
\]

where, \(k_E\) is the cost of equity; \(E\) is equity; \(k_D\) is the cost of debt; \(D\) is debt; and \(T\) is the corporate tax. \(k_E\) can be evaluated by the capital asset pricing model (CAPM) as Equation (5).

\[
k_E = k_F + \beta_A (k_M - k_F) \quad \text{Equation (5)}
\]

where \(k_F\) is the risk-free rate (e.g., return rate of government bonds); \(k_M\) is the market return rate; and \(\beta_A\) is the asset beta, which is related with sectors. \(k_E\) could also be influenced by the bargaining powers of the private sector in hazards. For example, the private sector will suffer substantial losses if the project goes bankrupt, but the government is not so eager to bail out the project. Considering this, the private sector is very likely to decrease their expected rate of return.

**Justification of the Proposed Model**
The proposed model makes light of the post contract lock-in effect in PPP projects, which is that the contractor’s bargaining power considerably changes in the post contract stage because
she made a lot of sunk investments in terms of relationship-specific assets. Economists argue that ex post bargaining games are only determined by the quasi rent of continuing project delivery, rather than the financial equilibrium, which has been used ex ante (Hart et al., 1997). Hence, the contractor is subject to a serious lock-in effect and easily held up by governments in PPP projects (Chang, 2013). However, that is not likely to be the case in PPP practices. Many safeguards have been provided to protect the contractor’s relationship-specific investments (e.g., government guarantees for serious risk scenarios and compensations for early terminations) (Xiong & Zhang, 2014a, 2014b), so ex post hold-up problems would not be as serious as economists perceive. Also, the third party (i.e., engineers) could significantly reduce hold-up problems in the post contract stage because it supervises contract implementation against opportunistic behaviors and reveals information for outsiders. Moreover, arbitrators and courts judge conflicts in PPP projects mainly based on the financial equilibrium, which is stated in the contract, rather than the quasi rent of continuing project delivery in serious risk scenarios; at last, using financial equilibrium as the foundation of ex post risk management can create a good relationship between the contractor and the government, and, consequently, encourage cooperation between them, which can significantly increase project performance (Xiong, Yuan, Li, & Skibniewski, 2015).

Selecting Ex Post Risk Response Measures

Once severe risk events are materialized, the government has to find a way to save the project based on the effectiveness and characteristics of risk response measures. In technical terms, the effectiveness index captures the extent to which the contractor’s financial status can be improved due to the unit change in one measure, and the characteristic indicates the applicability of one measure.

Concession Renegotiation

When serious risk scenarios occur and cause great difficulties to a PPP infrastructure project, both the government and the contractor can ask for concession renegotiation. Guasch (2004) found that the majority of renegotiations tended to favor the operator, while a small number of renegotiations favored the government. Engel, Fischer, and Galetovic (2009) found that renegotiations increased total investment by nearly one-third of their studied cases, but the majority was borne by future governments, or transferred to end users via higher tolls and contract extension.

The ex post risk response measures in concession renegotiation can rescue the project through compensating the affected stakeholders and transferring excessive risk impacts to other stakeholders. But many contractors seek opportunistic renegotiations, and huge public resources have been wasted in compensating them (Albalate & Bel, 2009). On the other hand, concession renegotiation could increase the flexibility of contracts and reinforce the durability of the public and private relationships (De Brux, 2010). In any event, once the project is confronted with serious risk scenarios, the government and the contractor should try their best to rescue it through concession renegotiation because early termination could result in more costs (HM Treasury, 2007). This study introduces six ex post risk response measures in concession renegotiation to reduce the financial impact of serious risk scenarios, and their reduction effectiveness and enforcement characteristics are explored as follows:

Toll Adjustment

The effectiveness of toll adjustment can be computed using Equation (6).

\[ e_1 = \sum_{t=1}^{T} d_t \lambda_t (1 - T) \]

where \( e_1 \) is the effectiveness of toll adjustment; and \( \frac{\Delta Q_t}{\Delta P_t} \) is the toll elasticity. But Loo (2003) and Matas and Raymond (2003) showed that the toll elasticity of traffic projects was very low. Thus, this study regards \( \frac{\Delta Q_t}{\Delta P_t} = 0 \). Then, \( e_1 \) solely depends on the future demand in the remaining concession. Toll increases can increase the revenue, on condition that the toll increase will not decrease the future demand dramatically. Toll increase has been well-accepted by both the contractor and the government in many cases because it effectively increases the revenue of the contractor without additional costs for the government. However, this measure transfers all the risks to the end user and probably induces dissatisfaction in the general public. Therefore, a toll increase should be used very carefully, especially when there have already been complaints for high toll rates. On the other hand, a toll decrease can also be used when the utilization of the project is far less than the design capacity or the general public complains about high toll rates. Since a toll decrease usually causes a reduction of revenue, it transfers the risks to the contractor.

Contract Extension

The effectiveness of contract extension can be measured as Equation (7).

\[ e_2 = \frac{\Delta \Psi(X)}{\Delta L} = d_t \lambda_t [(P_t Q_t - OC_L - FC_L - DC_L)(1 - T) + S] \]

where \( e_2 \) is the effectiveness of contract extension, and is determined by the net cash flow in year \( L \). A contract extension allows the contractor to collect more profits to cover risk impacts, only if the net cash flow in year \( L \) is positive. This measure is favored by governments because it can effectively solve the problems, and at the same time does not affect other stakeholders. However, it transfers all the risks to future governments. It can be used only if toll increase and government direct reimbursements are not available. It is hazardous for the
Ex Post Risk Management in Public-Private Partnership Infrastructure Projects

government to extend the expiry date because it simultaneously extends the government’s commitment to project risks (HM Treasury, 2007).

**Annual Subsidy or Unitary Payment Adjustment**

The effectiveness of an annual subsidy or unitary payment adjustment can be computed using Equation (8).

\[ e_5 = \frac{\Delta \Psi(X)}{\Delta S} = \sum_{t=1}^{T} d_t \lambda_t \]  

Equation (8)

where \( e_5 \) is the effectiveness of an annual subsidy or unitary payment adjustment. This measure compensates the contractor through government payment, and all the risks are transferred to the government. However, the government benefits from paying for the excessive risk impacts gradually in the remaining concession since the lump-sum payment may cause budget stress. The constraint of this measure is that the government must have enough funding for an annual subsidy or unitary payment. The subsidy can be in many forms, such as reduction in annual payment to the government, government guaranteed loans, and so forth. The unitary payment is usually direct reimbursement paid by the government, which is fixed or related to the quality or quantity of service/production delivery.

**Tax Waiver**

The effectiveness of a tax waiver can be computed using Equation (9).

\[ e_3 = \frac{\Delta \Psi(X)}{\Delta e} = -\sum_{i=1}^{L} d_i \lambda_i \]  

Equation (9)

where \( e_3 \) is the effectiveness of a tax waiver. A tax waiver is a discount of the tax rate. It transfers risks to the government. Unlike a pre-agreed subsidy, the amount of tax waiver is unknown at the time of renegotiation because the taxes are calculated based on the operational profits. For those unprofitable projects, the tax waiver may not be effective enough to cover all the excessive risk impacts, so it is widely used as a complementary measure.

**Reduction in Contractor’s Investment Obligations**

The effectiveness of reduction in contractor’s investment obligations can be measured as Equation (10).

\[ e_5 = \frac{\Delta \Psi(X)}{\Delta t} = -r \]  

Equation (10)

where \( e_5 \) is the effectiveness of reduction in contractor’s investment obligations and is determined by the reasonable rate of return \( r \). Reduction in the contractor’s investment obligations can compensate the contractor because the contractor can use the reduction of the investment to invest in other projects and acquire profits to cover the risk impacts in the failing project. Apparently, this measure is only used when a project has financial problems and further investment could be unprofitable. However, it is not a favorite choice for both the government and the general public because the reduction of investment will influence infrastructure development and public service supply. Therefore, this measure transfers risks to both the government and the general public.

**Adjustment Value**

With effectiveness being evaluated, the adjustment value (\( \Delta Y \)) for measure \( Y \) is calculated as Equation (11).

\[ \Delta Y = \Psi(X)/e_Y \]  

Equation (11)

Based on the adjustment values and the constraints, the government is able to select the most appropriate one or combination of *ex post* risk response measures in the concession renegotiation of a PPP infrastructure project.

**Early Terminations**

In order to encourage private sector investment in infrastructure, many governments promise to compensate investors in the case of early termination. For example, the Spanish concession law establishes that if a contract is terminated early, even if the reason is bankruptcy of the concessionaire, the government has to pay compensation to the concessionaire for the work already built and not yet depreciated (Vassallo, Ortega, & de los Ángeles Baeza, 2011). After compensation, the project assets and concession rights are transferred to the government. In some cases, the project assets and concession rights are sold to the new contractors, and governments do not have to compensate the contractor. Compensation is the core mission in early termination cases.

The previous literature described five methods to compensate the contractor at the termination of a concession. Particularly, the historical cost method compensates the book value of an asset when it was purchased; the inflation-adjusted historical cost method considers inflation in the compensation; the depreciated replacement cost method compensates for the cost of buying a new equivalent asset; the optimized depreciated replacement cost method compensates for the cost of replacing the asset with the cheapest alternative that does the same job; and the optimized deprival value method compensates for the net present value (NPV) of future earnings or the amount the asset could be sold for (HM Treasury, 2007; Kerf, 1998).

This study categorizes these compensation methods into three approaches as follows: (1) the compensation in the historical cost method and the inflation-adjusted historical cost method are based on the book value of the project assets, which can be evaluated through analyzing the financial statements—they are defined as compensation based on book value (BV); (2) the compensation in the depreciated replacement cost method and the optimized depreciated replacement cost method are based on the retendering price of the project assets, so they are defined as compensation based on retendering; and (3) the compensation in the optimized deprival value method
is the estimated market value of the remaining concession, which can be calculated through cash flow analysis, so it is defined as compensation based on market value (MV). Compensation based on retendering is not discussed in this study because this approach cannot be quantitatively analyzed, and the specific procedures and rules of retendering are available in HM Treasury (2007).

**Compensation Based on Book Value**

This approach calculates the compensation based on the book value of the project’s assets. No matter how much the project will lose or gain in the future, the compensation equals the unreimbursed cost (plus reasonable profits or default deductions on some occasions) at the termination date \( t_0 \). The formula is shown as Equation (12).

\[
Z_{BV}(X) = (1 + r)I - \sum_{t=t_0}^{T} d_t A_t \left[ (P_t Q_t - OC_t - FC_t - DC_t)(1 - T) + DC_t + S \right] \tag{12}
\]

where \( Z_{BV}(X) \) is the compensation to be paid by the government through the BV approach. Capital investment, price, demand, and other variables are all stated in the financial statements of the project, except that the reasonable rate of return is determined by negotiation between two partners. If the government terminates the concession unilaterally, and the contractor has no default, \( r \) is supposed to be the expected rate of return to protect the investor’s interest. However, if the early termination is caused by the contractor’s default, such as overestimation of demand, \( r \) should be much lower. The determination methodology of \( r \) can be pre-agreed in the contract.

From the perspective of the contractor, this approach is more appropriately used in projects without market value but with the utility charge set out in the contract. Similar projects include prisons, hospitals, schools, sewerage treatment plants, and so forth. In such cases, the only way for contractors to be recouped in early termination is from government compensation, which means that contractors have no alternatives, such as selling the project assets in the open market. Additionally, this approach is also satisfactory in the compensation of uncompleted projects. Without a clear picture of the total construction cost, project assets are very difficult to be sold out at real values. The potential new contractors prefer to offer a much lower price for uncompleted projects to cover construction risk. Another reason is that without the historical data on project performance (e.g., traffic demand), it is impossible to make a precise prediction for future revenues.

The main feature of the BV approach is that there are no uncertainties in calculating compensation because all the data are stated in the financial statements. The negotiations focus on the default responsibility and the associated deduction from the rate of return. Therefore, this approach is procedurally fast, and the project assets can be transferred to the government or the new contractor rapidly. However, governments take all of the long-term project risks in this approach because the compensation is not related to future performance. It is not value for money for governments to take over projects with poor performance.

**Compensation Based on Market Value**

In the MV approach, the government can compensate the contractor for the estimated market value of the remaining concession, in terms of the NPV of future cash flows. The compensation is shown as Equation (13).

\[
Z_{MV}(X) = \sum_{t=t_0}^{T} d_t A_t \left[ (P_t Q_t - OC_t - FC_t - DC_t)(1 - T) + (DC_t + S) \right] \tag{13}
\]

where \( Z_{MV}(X) \) is the compensation to be paid by the government through the MV approach. Unlike the BV approach, there are great uncertainties with the estimated value of the remaining concession. \( Q_t \) is one of the biggest sources of uncertainties, while overestimation of demand has caused many PPP infrastructure projects to fail, especially for transportation infrastructure projects (Vassallo et al., 2011). In addition, \( OC_t \) also fluctuates due to inflation and other risks. Actually, the compensation made by the MV approach is more representative of the real value of a project. When the remaining concession is sold on the open market, the tenders are buying a real option for collecting revenues in the remaining concession, instead of the project assets. Therefore, the book value of the contractor cannot reflect the real value of the project in this situation.

The MV approach is properly used in the compensation of PPP infrastructure projects that have substantial tariff revenues, such as traffic projects, water supply plants, and power plants. Once the construction is completed, the project can generate revenue, which can be used to repay the lenders and reimburse equity holders. In early terminations, the project has huge market value because of the revenue in the remaining concession. Thus, there is an alternative choice for the contractor offering sale on the open market, instead of sale to the government. If the government wants to buy out the concession, it has to offer a competitive price for the deal because the contractor has the ability to bargain with the government (Wilbur Smith Associates Limited, 2011).

In this approach, contractors take all long-term risks because the future cash flows for compensation are estimated based on project performance before early termination. Thus, if contractors do not perform well in construction or operation, or make severe errors in demand forecasting, the compensation from the government should be low. On the other hand, if the contractor behaves very well and the market is also good before the termination, the government has to pay a great amount of compensation to the contractor in early termination.
Application Significance

This article belongs to a series of research concerning renegotiations and early terminations in PPP projects (Xiong & Zhang, 2014b, 2016; Xiong, Zhang, & Chen, 2015; Zhang & Xiong, 2015). However, we found that practitioners in both the public and private sectors do not prefer the term of renegotiation and early termination in their communications because it is easy to relate them to project failures. On the other hand, risk management has been widely used in PPP projects, and it is more acceptable for practitioners if renegotiation and early termination are indeed involved in the framework of ex post risk management.

The ex post risk management also emphasizes an important issue in project risk management that has been ignored by scholars for a long time (i.e., the costs of ex ante risk management). Theoretically, all risks can be dealt with appropriately through excellent ex ante risk management, but the cost associated with such works could be tremendous. Previous literature relating to project risk management generally concerns the risk indexes of different projects and advanced techniques for risk analysis, but practitioners indeed care about a trade-off between the benefits and costs of risk management. That is why renegotiations and early terminations are very common in PPP projects.

The proposed ex post risk management model is mainly applied for decision making in the serious risk scenarios of PPP projects. When one party’s risk tolerance is exceeded, the government should propose ex post risk response measures to take care of the excessive risk impacts. A three-step protocol is suggested as follows: (1) risk impact assessment, referring to Equations 2 through 5; (2) risk response effectiveness assessment, referring to Equations 6 through 13; and (3) risk response measures selection, which is based on the effectiveness assessment. An illustrative case is shown in the Appendix to show the applicability of the proposed ex post risk management model.

Moreover, the application of ex post risk response measures should also consider the enforcement constraints of the project. In renegotiations, if the government is more worried about public satisfaction, such as in the year of a general election, a toll increase will not be selected because it may cause public opposition; if the government has budget constraints, then annual subsidy and unitary payments are not preferable because they may involve a huge slice of the government budget; if the government is keen to absorb private funding to develop infrastructure, reduction of investment obligations is unlikely to be selected. In early terminations, if compensation for early termination through the MV method is applicable, but it is difficult for the partners to achieve a consensus on future cash flow estimation, compensation for early termination through the BV method could be used; the partners can then negotiate the rate of return instead of future cash flow estimation.

Conclusions

Serious risk scenarios have forced governments to take measures to renegotiate or terminate many PPP infrastructure projects. The criteria for justifying serious risk scenarios are risk tolerances. A clear declaration of the commercial and production risk tolerances in agreements can be very helpful for risk management. Aiming at tackling these serious risk scenarios, a quantitative ex post risk management model was well-proposed in this study. The ex post risk response measures in concession renegotiation and early termination were discussed in detail as well. The potential applications are discussed and an illustrative case demonstrated the good applicability of the quantitative ex post risk management model.

This study clarified the risk management principles and developed the conception of ex post risk management based on the literature of hazard management. Confronted with serious risk scenarios, ex post risk management can reduce the excessive risk impacts and bring the project back to appropriate operation. The objective function is based on the financial equilibrium, which is a well-accepted body of knowledge in PPP research. The application of this model begins with risk impact evaluation, then ex post risk response measures assessment, selection, and enforcement. The common measures in concession renegotiation include toll adjustment, contract extension, annual subsidy, or unitary payment adjustment, tax waiver, and reduction in the contractor’s investment obligations; and the common measures in early termination are the BV and MV compensation methods.

Different ex post risk response measures have different reduction effectiveness and enforcement characteristics in application. A set of equations were developed based on the general model to evaluate the reduction effectiveness of these measures. A suitable measure can be selected according to its enforcement characteristics. The toll adjustment has to consider the end user’s ability to tolerate high toll rates; the contract extension must be cautiously adopted since huge risks may emerge for future governments; the annual subsidy or unitary payment adjustment may cause stress for the government budget; the tax waiver is usually not adequate for compensation; the reduction in contractor’s investment obligations may influence the development of infrastructure; the BV approach is suitable for utility charge-based projects and uncompleted projects, and the MV approach is suitable for tariff-based projects.

Contributions to the Body of Knowledge

There are two main contributions of this study. First, this study develops a framework for ex post risk management, which has long been ignored in the literature. The conventional wisdom of risk management is solving all the risks ex ante.
through a well-designed contract, but frequent occurrence of renegotiations and early terminations shows that ex ante risk management is not sufficient for projects that are extremely complex and risky, such as PPP infrastructure projects. The ex post risk management is a complement of ex ante risk management and can be used to deal with risks dynamically in the long concession period of PPP projects. The framework can be a foundation for future studies of renegotiations and early terminations in PPP projects. Second, this study proposes a quantitative ex post risk management model, which involves a series of ex post risk response measures in concession renegotiation and early termination. There has been some literature about renegotiation and early termination in PPP projects, but most literature concerns particular types of them, such as that from Xiong and Zhang (2014b), which develops concession renegotiation models for three types of renegotiations and that from Xiong, Zhang, and Chen (2015), which builds a compensation model for early termination based on the MV method. The ex post risk management model involves seven different types of risk response measures and compares their effectiveness and characteristics, so it enables the decision makers to select the most suitable one in serious risk scenarios.

Limitations and Future Research

A main limitation of this research is that the illustration of the ex post risk management approach is based on a hypothetical case. Since the quantitative model is original and not applied in real life PPP projects, much effort should be devoted to applying and testing this model in the future. Some suggestions for future research are as follows:

1. The execution of renegotiations and early terminations should be studied. This research only constructs a theoretical framework and conceptual models for an ex post risk management approach, but more executive insights on how the proposed approach may be written into initial contracts are needed.
2. The transaction costs of different risk response measures should be evaluated. In the choice of risk response measures, effectiveness and characteristics are certainly main concerns, but transaction costs of different measures are also important.
3. The hold-up problems in ex post risk management can be investigated. The authors build the objective function of ex post risk management based on the financial equilibrium. Nevertheless, we do not exclude the possibility of hold-up problems, so combining hold-up problems and financial equilibrium in ex post risk management is a topic for future research.

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Appendix: An illustrative case.

Project Background

In order to illustrate the application of the ex post risk management, this study presents a toll highway concession comprising a two-year construction phase and 35-year operation phase. The assumptions made, as shown in Table 2, refer to the case in Shan, Garvin, and Kumar (2010). The government offers a guarantee of a minimum rate of return for equity (7.5%), which is slightly higher than the interest rate (7%), but is much lower than the expected rate of return for equity (72%). The capital investment comprises 80% debt and 20% equity. Since the minimum rate of return has been guaranteed at the outset, any breach can be defined as a serious risk scenario.

<table>
<thead>
<tr>
<th>Operating Variables</th>
<th>Capital Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial traffic volume per day</td>
<td>Capital cost</td>
</tr>
<tr>
<td>Annual traffic growth rate (year 1–10)</td>
<td>US$110,000,000</td>
</tr>
<tr>
<td>Annual traffic growth rate (year 11–20)</td>
<td>80% D/A</td>
</tr>
<tr>
<td>Annual traffic growth rate (year 21–35)</td>
<td>US$88,000,000</td>
</tr>
<tr>
<td>Initial toll</td>
<td>2.00% Equity</td>
</tr>
<tr>
<td>Annual toll growth rate (year 1–5)</td>
<td>US$22,000,000</td>
</tr>
<tr>
<td>Annual toll growth rate (year 6–10)</td>
<td>6.00% Risk-free rate</td>
</tr>
<tr>
<td>Annual toll growth rate (year 11–35)</td>
<td>3.00% Minimum rate of return for equity</td>
</tr>
<tr>
<td>Initial O&amp;M cost</td>
<td>7.00% Interest rate</td>
</tr>
<tr>
<td>Annual growth rate of O&amp;M cost</td>
<td>2.00% Debt service coverage period (year)</td>
</tr>
<tr>
<td>Initial subsidy</td>
<td>15</td>
</tr>
<tr>
<td>Annual growth rate of subsidy</td>
<td>3.00% Expected rate of return for equity</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Table 2: Project information for case illustration.</td>
<td></td>
</tr>
</tbody>
</table>

Since most of the renegotiations occur in the first two years of operation (Guasch, 2004), this study assumes that the contractor claims for renegotiation after the project has been operated for two years (year four) because of certain serious risk scenarios. The serious risk scenarios could be caused by the following driving risks: demand shortfall, construction cost overrun, O&M cost overrun, and public rejection of toll rate (Cruz & Marques, 2013a). As shown in Table 3, the serious risk scenario is “Yes” if the rate of return for equity is lower than 7.5%; otherwise, it is “No.”

Risk Impact Assessment

The risk impact is evaluated by the shortfall of the actual profit from the guaranteed profit. The severity of driving risks is represented by “M.” The severity of demand shortfall, O&M cost overrun, and public rejection of toll rate is defined as the variance between the actual and planned initial traffic volume, initial O&M cost, and initial toll rate, respectively. It should be noted that the annual growth rate of traffic volume, O&M cost, and toll rate is assumed to be unchanged. That’s because it is impossible to predict the long-term growth rate trend while the project only has historical data for two years. The severity of construction cost overrun is defined as the variance between the actual and planned capital investment. Sensitivity analysis is also conducted using different risk severities, as shown in Table 3.

<table>
<thead>
<tr>
<th>Driving Risks</th>
<th>Rate of Return (M = 10%)</th>
<th>Serious Risk Scenarios (Y/N)</th>
<th>Rate of Return (M = 20%)</th>
<th>Serious Risk Scenarios (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand risk</td>
<td>-55%</td>
<td>Y</td>
<td>-240%</td>
<td>Y</td>
</tr>
<tr>
<td>Construction cost overrun</td>
<td>14%</td>
<td>N</td>
<td>-15%</td>
<td>Y</td>
</tr>
<tr>
<td>O&amp;M cost overrun</td>
<td>8%</td>
<td>N</td>
<td>-57%</td>
<td>Y</td>
</tr>
<tr>
<td>Public rejection of toll rate</td>
<td>-55%</td>
<td>Y</td>
<td>-240%</td>
<td>Y</td>
</tr>
</tbody>
</table>

*M = the severity of driving risks

Table 3: Risk impact evaluation.
According to the risk impact simulation, the case falls into a serious risk scenario when the severity of the demand shortfall or the public rejection of the toll rate is 10%, and when the severity of any risk is 20%. With the same severity, the demand shortfall and the public rejection of the toll rate have the same impact, which is higher than that of construction cost overrun and O&M cost overrun. Even though serious risk scenarios may be caused by a combination of risks, this study only analyzes the risk individually for sample illustration.

**Effectiveness Assessment**

After the risk impacts of driving risks are evaluated, *ex post* risk response measures can be taken. Among the available measures, the government has to assess the reduction effectiveness, determine the adjustment values, and select the most suitable one. Even though the government can also select a combination of measures, this study only analyzes individual measures for sample illustration. The adjustment values of all the available measures for the illustrative case are calculated when the severity of driving risks is 20%, as shown in Table 4.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Equations Applied</th>
<th>Demand Risk (Million US$)</th>
<th>Construction Cost Overrun (Million US$)</th>
<th>O&amp;M Cost Overrun (Million US$)</th>
<th>Public Rejection of Toll Rate (Million US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk impact (Million US$)</td>
<td>(2), (3)</td>
<td>54.55</td>
<td>9.73</td>
<td>14.18</td>
<td>54.55</td>
</tr>
<tr>
<td>Toll increase (US$)</td>
<td>(6), (11)</td>
<td>0.50</td>
<td>0.07</td>
<td>0.10</td>
<td>NA</td>
</tr>
<tr>
<td>Contract extension (year)</td>
<td>(7), (11)</td>
<td>11</td>
<td>3</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Annual subsidy or unitary payment</td>
<td>(8), (11)</td>
<td>246%</td>
<td>44%</td>
<td>64%</td>
<td>246%</td>
</tr>
<tr>
<td>Reduction of investment obligations</td>
<td>(9), (11)</td>
<td>NE (7576%)</td>
<td>50%</td>
<td>NE (143%)</td>
<td>NE (7576%)</td>
</tr>
<tr>
<td>Compensation of early termination BV</td>
<td>(10), (11)</td>
<td>75.76</td>
<td>13.52</td>
<td>19.70</td>
<td>75.76</td>
</tr>
<tr>
<td>Compensation of early termination MV</td>
<td>(12)</td>
<td>139.44</td>
<td>165.08</td>
<td>139.07</td>
<td>139.44</td>
</tr>
<tr>
<td>Compensation of early termination</td>
<td>(13)</td>
<td>73.14</td>
<td>153.25</td>
<td>121.83</td>
<td>73.14</td>
</tr>
</tbody>
</table>

*NA = Not Applicable; NE = Not Effective Enough.*

**Table 4**: *Ex post* risk response measures evaluation.

**Ex Post Risk Response Measures Selection**

The selection of most suitable *ex post* risk response measures depends on their effectiveness in solving problems. The evaluation of *ex post* risk response measures is shown in Table 4. With regard to renegotiations, a toll increase is very effective in this case because a US$0.50 toll increase would adjust off all excessive risk impacts, except that a toll increase is not applicable when the driving risk is public rejection of toll rate; contract extension is also effective, but it is dangerous for the government to extend the concession by nearly one-third of original length when the driving risk is demand shortfall or public rejection of toll rate; annual subsidy or unitary payment is direct and effective, but it occupies a huge amount of budget, which is up to around US$2.5 million per year when the driving risk is demand shortfall or public rejection of toll rate; tax waiver is effective when the driving risk is construction cost overrun, but is not effective enough when the driving risk is demand shortfall, O&M cost overrun, or public rejection of toll rate; reduction of investment obligations is effective only if there is such an amount of investment obligation in agreements. With regard to early terminations, compensation for early termination through the BV method is applicable, if the driving risk is caused by the government or has been assigned to the government in agreements, and the compensation is much higher than the capital investment; compensation for early termination through the MV method is applicable, if the driving risk is caused by the private sector or has been assigned to the private sector in agreements, and the compensation is lower than the capital investment when the driving risk is demand shortfall or public rejection of toll rate.
INTRODUCTION

Public investment projects amount to large sums, both in relative terms and absolute figures. The McKinsey Global Institute (2013) estimates global infrastructure spending to be at 4% of the total global gross domestic product, mainly delivered as large-scale projects. However, public investment projects face a number of challenges and have varying reputations. There is broad literature on what Hall (1981) termed "great planning disasters," which are projects with cost overruns, time delays, and either no benefits or very limited benefits, and that are sometimes so controversial and infeasible that they end up being closed down or severely altered. The problem of cost overrun is particularly well documented (Morris & Hough, 1987; Flyvbjerg, Skamris Holm, & Buhl, 2003a; van Wee, 2007). For example, Flyvbjerg et al. (2003a) analyzed 258 infrastructure projects in 20 countries over a period of 70 years, and concluded that the cost overruns were significant and the situation had not improved during the period. The more serious, but equally common, problem is when projects do not meet the expectations of users and society. For example, Pinto (2006, p. 7) quotes from an Infoworld article describing, "a U.S. Army study of IT projects [that] found that 47% were delivered to the customer but not used; 29% were paid for but not delivered; 19% were abandoned or reworked; 3% were used with minor changes; and only 2% were used as delivered." Similarly, Flyvbjerg, Bruzelius, and Rothengatter (2003b) showed that benefit shortfalls are a consistent problem in the transport sector.

These problems are not limited to the public sector—see, for example, Merrow (2011), who documents similar challenges in the private sector. The public sector, however, has some additional challenges, including multiple objectives, difficulties in measuring success, and having to deal with a wide array of external stakeholders in the democratic decision-making processes (Klakegg & Volden, 2016). Public projects are the outcome of a political tug-of-war between stakeholders in society, whose needs and priorities will concur or conflict to varying degrees. The outcomes of such processes are not always predictable. This is clearly shown in Miller and Lessard’s study of 60 international projects (Miller & Lessard, 2000). Some authors emphasize dishonesty and "strategic explanations" as the causes of project failure, including deliberate misrepresentation in project appraisal by promoters (Flyvbjerg et al., 2003b), which is referred to as “perverse incentives” by...
Volden and Samset (2015). However, the public sector, too, has some internal challenges, such as a weak capacity for designing a strategic vision, lack of skills, and lack of coordination among levels and actors, as noted by the Organisation for Economic Co-operation and Development (OECD) (2015b).

The very largest of such projects are the most crucial: they are “too big to fail,” they are very expensive, and they have high levels of inherent uncertainty and risk (Le Quesne & Parr, 2016). Special measures are therefore required to ensure successful implementation and outcome. In order to deal with these challenges, some governments have established designated governance schemes for the very largest projects. Norway was a pioneer in this endeavor and introduced an overarching framework for the governance of major public projects in the year 2000. See, for example, Volden and Samset (2017) for a presentation of the Norwegian framework and its effects, some of which are very encouraging; other countries have introduced similar frameworks in recent years. In this article we provide a description and a comparative analysis of how such project governance schemes are currently being organized and handled at the central government level in six countries: Norway, the United Kingdom, Denmark, the Netherlands, Canada (Quebec Province), and Sweden.

Common to all schemes is that they are intended for project governance by a central government and applied to projects that involve particularly high costs, risk, and complexity, or are highly innovative. For example, in Norway, there are 20 to 30 such projects annually.

Our contribution to the literature is the compilation of a set of innovative project governance schemes, in which we highlight their differences and similarities and present the preliminary evidence of their impact. The results should not only be of academic interest, but also should provide information for other countries considering the introduction of similar mechanisms for improving the success of major public projects, including the OECD’s ongoing work to establish a common framework for governance and delivery of infrastructure (OECD, 2015b), which seems to have focused more on delivery models and less on the strategic project perspective. All schemes are relatively recent, however; therefore, it is too early to determine with certainty their impact and degree of success, and this should be a topic of future studies.

This article starts with definitions of key concepts and principles related to project governance and presents key findings from the literature, while highlighting the importance of the front-end phase and role of central government. Each country’s governance scheme and its underlying stage-gate models are described, as well as the involved parties and their roles, the use of independent quality assurance in the process, and a number of other elements. Similarities and differences between the schemes are explored to discuss the significance of principles and practices of the different approaches to project governance.

Governance of Public Sector Investment Projects

Goverance

In general terms, governance relates to "all of processes of governing, whether undertaken by a government, market or network, whether over a family, tribe, formal or informal organization or territory and whether through the laws, norms, power or language" (Bevir, 2013, p. 1). The term governance means "to steer". In political science, it refers to what happens at the government level in a society. It concerns the role of government in facilitating the attainment of societal objectives. The government generally has three types of policy instruments at its disposal: the stick, the carrot, and the sermon, corresponding to regulation, economic means, and information (Bemelmans-Videc, Rist, & Vedung, 1998). The instruments may be either affirmative or negative. The model has its parallel in the regime of the World Bank (World Bank, 2000), in which the regulation element is described in terms of rules and restrictions, the economic element in terms of competition pressure, and the information element in the forms of transparency and assistance.

Governance is often used as a normative concept, whereby the quality of governance is compared to a standard of "good governance." For example, the United Nations Development Programme (UNDP) (2006) defines good governance as “among other things participatory, transparent, and accountable. It is also effective and equitable. And it promotes the rule of law” (our italics). Similarly, the Council of Europe (2014) suggests 12 principles for good governance, including sustainability (long-term orientation) and competence and capacity. Regardless, the social and economic consequences of poor governance policies and systems may be considerable.

A related term is corporate governance, which refers to the mechanisms, processes, and relations by which corporations are controlled and directed. Müller (2009) distinguishes between the traditional "shareholder perspective," which limits corporate governance to a question of how to incentivize management to deliver good financial results, and the "stakeholder perspective," which is broader and takes a wide range of other stakeholders into account. According to the OECD (2015a), good corporate governance involves a set of relationships between the organization’s management, its board, its shareholders, and other stakeholders. Moreover, good corporate governance requires a structure defining how the organization’s goals should be determined, how such goals should be realized, and how this should be followed up (OECD, 2015a).

Project Governance: Principles and Components

The term project governance has only recently become an important issue in the project management community and literature. It refers to the processes,
systems, and regulations that the financing party must have in place to ensure that projects are successful (i.e., that relevant and sustainable project alternatives are chosen and delivered efficiently) (Volden & Samset, 2017). The Project Management Institute (PMI) (2013) defines project governance in a similar way, as “an oversight function that is aligned with the organization’s governance model and that encompasses the project life-cycle [by providing] a comprehensive, consistent method of controlling the project and ensuring its success by defining and documenting and communicating reliable, repeatable project practices.” A key project governance issue is that the interests of the implementing agent will not necessarily be aligned with those of the financing party or project owner. Project governance seeks to ensure that an implementing agent, in this case represented by the project manager, will act in conformity with the interests of the owners (Tirole, 2001). Project governance is thus a system of appropriate checks and balances that enables transparency, accountability, and defined roles, while at the same time supporting project managers in delivering their objectives. This corresponds well with what Morris and Geraldi (2011) define as the institutional level of managing projects, which focuses on shaping the context and conditions to support and foster projects, although Morris and Geraldi focus more on the support function than the governance function. As noted by Crawford et al. (2008), there is a possible conflict of interest facing a project sponsor (owner), between the “governance perspective” and the “support perspective.” On one hand, the sponsor should have an external focus, representing the enterprise and the client’s interest, and on the other hand, he or she must have an internal focus, providing project management with support to fulfill their role efficiently. Crawford et al. find that the sponsor role is played out quite differently in different organizations. In our study, the focus is primarily on the governance perspective.

Various definitions and typologies of project governance are suggested in the literature. Williams, Klakegg, Magnussen, and Glasspool (2010) distinguish between governance of projects, which aims at efficient delivery, and governance through projects, which aims at choosing the right concepts and ensuring that effects are realized and are sustainable. Müller, Shao, and Pemsel (2015) distinguish between project governance and governance of projects, where the former refers to the governance of a single project, and the latter to the governance of groups of projects, such as a program or portfolio. In a similar manner, Too and Weaver (2014) note that publications discussing project governance can be classified into two main groups. The first group focuses on governance of single projects, typically involving several actors and stakeholders, when a contract will specify the specific governance arrangements for that project. The second group of publications examines governance models linking different project-related levels (project, program, and portfolio) within an organization, and thus sees project governance as a subset of corporate governance. In our study, the focus is on governance schemes applying to all major investment projects at the national level. Accordingly, our perspective is the governance of projects in Müller’s terminology, but we take the central government perspective rather than a given organization’s perspective. A natural implication is that we emphasize governance through projects somewhat more than the governance of projects (cf. Williams et al., 2010).

Flyvbjerg et al. (2003b) discusses which criteria should underpin mega-project governance regimes. Based on a large set of empirical data, they found that the main problem with major public projects is that the stakeholders have a self-interest in their implementation (whether financial or political); they underestimate the risk and they are not held accountable to central government, which adopts a more overarching perspective of maximizing public benefits. The authors talk about the “mega-project paradox,” and propose the following alleviating measures:

1. Risk and accountability must be accorded much more of a key role in decision-making processes.
2. Risk analysis and risk management requirements must be imposed.
3. The authorities should remain at “arm’s length” and not become involved in promoting the project, but limit their role to formulating overarching objectives and ensuring that such objectives are attended to by the project.
4. In order to bring about responsible decisions, one should:
   • ensure transparency;
   • specify performance requirements;
   • impose clear requirements for the construction and operation of the project; and
   • involve capital from private investors since their willingness to invest will be a project viability test.

Haanes, Holte, and Larsen (2006) reviewed different models for decision making in major public projects based on best practice in Norway and other countries and suggest the following minimum requirements:

• Clearly defined project phases
• Clearly defined decision points
• Quality assured basis for the decisions
• Simplicity
• Some degree of standardization and common terminology

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[Project governance includes, among many other things, the governance part of the project management methodology, the role of the steering group, and the sovereignty and authority with which the project manager can manage his or her project. By contrast, governance of projects includes issues such as the level of institutionalization of project management, for example by using similar reporting systems, methodologies, or project selection techniques across the group of projects (Müller et al., 2015).]
Likewise, Narayanan and DeFillippi (2012) state that project governance schemes should incorporate five elements: stage-gate approval processes, formal roles and responsibilities, stakeholder representation, quality assurance, and contracts and sign-offs.

More recently, several standards and guides have been developed to address project governance models, in particular as part of corporate governance. For example, the Association for Project Management (APM, 2011) has established 13 principles for the governance of project management, and has defined four main components of schemes that adhere to them:

1. Portfolio management—ensuring that each project is aligned with key business objectives
2. Project sponsorship—providing a link between the permanent and the temporary organization, typically by defining a project sponsor or project board as the “governance agent,” with decision making, directing, and representational accountability
3. Project management capability—ensuring that the teams responsible for projects are capable of achieving the objectives that are defined at project approval points, which is a question of skills, available tools and processes, and a clear mandate (among others)
4. Disclosure and reporting—ensuring that project reports provide timely, relevant, and reliable information that supports the organization’s decision-making processes, without fostering a culture of micro-management

Such principles and guides may be more or less detailed, and more or less mandatory. Some project governance models are behavior oriented, requiring that certain detailed rules are followed (e.g., common project management methodology), whereas others are outcome oriented and give more autonomy to the project manager. These two “paradigms” may also be denoted as bottom-up and top-down (Müller, 2009). The top-down model is more often found in organizations with a high level of trust and a high level of project management skills.

Some organizations have established project management offices (PMOs). A PMO is an internal group or department that defines and maintains standards for project management; provides training, monitoring, and reporting on active projects and portfolios; and, in some cases, takes a more strategic role, acting as the owner of the project portfolio. PMOs may take many forms, as demonstrated by Hobbs and Aubry (2008), but they often have a central role in a project governance model (Morris & Geraldi, 2011; Müller et al., 2014).

In this article, we focus more on the structural than the non-structural elements of project governance. However, it should be noted that project governance is not only about laws and regulations, as it is not possible to determine every action. Based on Foucault’s work, Müller et al. (2014) introduced the term governmentality in the project management literature. Governmentality is a combination of “governance” and “mentality,” and addresses the human side of governing—the attitude that governors have toward those they govern, and whether governance is enforced through strict rules or through soft “cultural” values that members of an organization share and respect. Similarly, Klakegg and Meistad (2014) divide governance into structure-based and relationships-based governance. The former incorporates the elements mentioned above, such as stage-gate approval processes, roles and responsibilities, and quality assurance; whereas relationships-based governance typically includes non-hierarchical elements such as leadership, motivation and incentives, resource allocation, trust and ethics, alliances and involvement of stakeholders, informal relations, and communication.

According to Miller and Hobbs (2005), large complex projects will require a governance system that is not static and hierarchical, such as is commonly used for smaller projects. There needs to be scope for changes along the way, because both the planning and implementation phases of large public projects last for a long time. Governance will therefore assume different forms in the various phases of the project cycle. This highlighting of flexibility is supported by Müller et al. (2014), who seek to identify “organizational enablers” for good governance and governamental. The most prevalent finding of their study is the importance of flexibility—the lower levels of governance require flexibility in the choice of methods and processes, whereas the higher levels of governance require flexibility in people’s mindsets and attitudes toward work. Furthermore, there are needs for vision and values provided by top management and management’s development of a culture that fosters flexibility and self-responsible employees.

The Importance of the Front-End

A project’s life cycle consists of several phases (Figure 1). The front-end phase is the stage when the project only exists conceptually, before being operationalized. This encompasses all activities from when the idea is conceived until a final implementation decision is made. A distinction is commonly made between the conceptual phase, the pre-study, and the pre-project, as shown in Figure 1. In the conceptual phase, the conceptual solution and the overall project strategy are decided, and thus the key premises underpinning the project, as well as its characteristics and objectives. In the pre-study and pre-project phases, the decisions are more concrete with regard to contractual strategy, mode of delivery, and subsequently the detailed project design with regard to budget, activities, scope, schedule, and quality. This is followed by the implementation phase, which encompasses anything that happens after a final funding decision has been made, and includes detailed engineering and actual construction. Finally, the operational phase consists of commis-
A governance framework for the full life cycle of the project should be prepared at the outset, given that certain phases are more critical and in need of governance arrangements than others (HM Treasury, 2007). A number of authors have highlighted the importance of paying more attention to the front-end of projects to ensure project success (Shenhar, 2004; Williams & Samset, 2010; Morris, 2013, Samset & Volden, 2016). Morris (2013) highlights the importance of taking a holistic and “big picture” perspective on the project, and notes that in the early years, the project management community had an extremely narrow focus, reflecting only on the project itself and ignoring the critical front-end phase in which the most essential and overarching issues are decided. Many of the factors that later create problems in the construction phase, leading to projects delivering too late and over budget, arise early in the project definition stage (Morris, 2009). Williams and Samset (2010) note that the choice of concept has the largest impact on strategic project success and is thus highly critical. Other fundamental issues in the front-end are: to ensure realistic cost estimates (and counteract tactical budgeting); to ensure a rational planning process and a transparent democratic process; and to achieve predictability over time, since the front-end phase often extends over more than one parliamentary cycle.

A study of more than 1,000 projects, conducted by the World Bank, may provide solid evidence for the importance of the front-end phase (World Bank, 1996). A thorough review of the scope and quality of prior checks, prior assessment, and project design before the implementation of projects was linked to whether these turned out to be successful or not when examined in retrospect. The World Bank concluded that no less than 80% of the thoroughly prepared projects were successful, whereas as much as 65% of those initiated without proper preparation turned out to be unsuccessful. A corresponding study of 23 Norwegian projects delivered similar findings (Whist & Christensen, 2011).

The “Top Layer” and the Role of Central Government

This study is concerned with project governance from the perspective of central government, regarding investment projects that are funded by the state and implemented by line ministries and state agencies. In Norway, municipalities and counties are responsible for their own investments and may have their own governance schemes, which are not discussed here. We discuss how the governance of projects is currently organized and practiced at the overarching level. A governance framework is hierarchical, in the same way as a management system, where the top level is accountable for the whole system but delegates the responsibility and authority for defined actions to subordinate levels (Too & Weaver, 2014). Thus, central government, ultimately on behalf of the whole population, should set the conditions for projects (as well as other public sector activities) to deliver value to society; it should also impose overarching requirements with regard to, for example, structures, processes, and outcomes, but should not intervene in detailed project implementation (Samset, Berg, & Klakegg, 2006). Responsibility for implementing projects and programs is delegated to the different line ministries and agencies, which define the specific governance arrangements necessary to ensure tactical and operational project success.

Taking “the central government perspective” does not imply that we believe that central government can always be regarded as one unit and that all government decisions are made rationally. In practice, public project decisions are made through political processes in which agreements about goals and fundamental assumptions cannot be taken for granted (O’Leary, 2012), and in which there are many examples of irresponsible behavior, even from the top level (Miller & Hobbs, 2005). It is important to note that project governance structures and processes, which focus more on improving administrative processes than on political processes, do not ensure good decisions; they simply provide the framework within which good decisions can be made. This is probably the best one can do within a democratic political system.

An important part of governance schemes should be to ensure that decisions are lifted up to the appropriate level. Accordingly, the government itself should be involved in the management process on a strategic level, such as approving very large and critical projects. This is in line with the reform processes often referred to as Post-
New Public Management (Christensen, 2009), which is based on the premise that such an approach will enhance effectiveness and efficiency, without losing political impact.

The Study, Selected Countries, and Methodology

The starting point for this study was the Norwegian project governance framework, which the authors have followed for a number of years. The framework was an attempt to resolve or mitigate some common challenges observed in public projects in the 1990s, and the preliminary results are encouraging (Volden & Samset, 2017). However, it is only one of many possible ways to set up a project governance scheme, and our intention has been to review replicable systems in other selected countries, relate them to the Norwegian system and each other, and to discuss the following questions: Are they apt to ensure project success as intended? What are the differences and similarities between the schemes? What can Norway learn from the other countries and vice versa?

The other countries included in this study—the United Kingdom, Denmark, the Netherlands, Canada (Quebec Province), and Sweden—were selected primarily because they too are at the forefront in developing a public sector investment project governance system, with schemes introduced after the turn of the millennium. Quebec is merely one of several provinces of the Canadian Confederation, but has extensive independence in the area of infrastructure investments, and is included with the other studied countries due to its early initiative and advanced project governance scheme. Another determining factor was that all of the studied countries were OECD countries with a high level of economic development. There are, however, significant differences between the countries, not the least in their demographic and natural conditions, which implies that they differ also in their economic prospects for developing infrastructure. Norway (and to some extent also Sweden and Quebec) has a small population, long geographic distances, and areas that are virtually uninhabited, but nonetheless has a broad political consensus that the scattered and remote settlements should be maintained by building roads and public infrastructure. It is therefore obvious that the criteria for project selection may include societal objectives other than “value for money” in economic terms.

Two existing studies have compared the Norwegian governance framework with the British one (Williams et al., 2010), and with the British and Dutch frameworks (Klakegg, Williams, & Shiferaw, 2015), respectively. These studies constitute an important background for our study. Williams et al. (2010) conducted a case study and concluded that in all the four projects examined, the governance framework was useful in its own way, but also that there was some potential for improvement, such as more assessment of the project during the early stages (which has since been introduced in the United Kingdom). Klakegg et al. (2015) conclude that consistent project governance provides rewards, but they note that effort must be made to preserve the effect, otherwise it might “wear off.” Another relevant study was conducted by Trafikanalyt (2012), which has presented and discussed the systems regarding planning and assurance of transport projects in the Nordic countries, focusing mostly on cost figures. Other than the above-mentioned studies, we are not aware of any studies focusing on project governance models on a country level. Our study comprises more up-to-date descriptions of the governance frameworks in the same three countries as those studied by Klakegg et al. (2015), along with three additional countries. It is still no more than a case study, but it allows for comparisons that are somewhat more systematic and for evaluations of the development, content, context, and preliminary effects of the governance frameworks.

Some countries have more than one scheme, for example, depending on the sector. In these cases, we restrict the study to the governance models that concern the largest sectors measured by investment volume. Other schemes are cross-sectoral, such as the United Kingdom, Quebecian, and Norwegian schemes, and apply to all types of infrastructure investments. A common feature of all schemes, however, is that they are used for large investment projects that entail high costs or are highly complex.

This study is principally based on document reviews, backed up with interviews with key informants at the ministry level in the relevant countries and/or persons with special knowledge of the various schemes, in order to obtain documentation and verify the descriptions of the schemes. The documentation provided by the governments has varied. In some countries, the authorities have provided thorough descriptions of their schemes, and in the United Kingdom they have even made evaluations publicly available, whereas in other countries limited descriptions have been provided; therefore, we have had to supplement them with other sources, such as research reports and interviews. The information concerning the scheme in the Netherlands was primarily obtained from a doctoral dissertation that focused specifically on that scheme (Shiferaw, 2013).

In order to compare governance in the various countries, we have examined the development and content of the schemes, including which objectives countries have defined for them, which internal and external parties have been involved, their duties and responsibilities, how decisions have been made at the political level, and how the schemes have been structured at the project level. The reference point has been a scheme adhering to the recommendations from the literature, including both the overall principles of good governance and the more specific recommendations concerning project governance schemes. These principles and recommendations include stage-gate
approval processes with clearly defined phases, decision points and quality assurance, highlighting the front-end lifting decisions to a high political level, being simple and flexible, promoting a portfolio perspective, and transparent processes and decisions.

The Governance Schemes

Norway

The background to the Norwegian governance scheme was a series of negative experiences with cost overruns, delays, and limited viability of some public investments in the 1990s, resulting in a government-initiated study to review the systems for the planning, implementation, and monitoring of large public investment projects. The authors of the study (Berg et al., 1999) concluded that the underlying documentation was deficient in a number of projects and that failures in the front-end phases were generally the main cause of problems during implementation. The authors proposed the introduction of an external quality assurance (QA) scheme in the decision phase for the largest public projects.

The QA scheme, introduced in the year 2000, is often referred to as the State Project Model, and is mandatory for investment projects with an anticipated budget exceeding 750 million Norwegian Kroner (approximately US$90 million). It involves some 20 to 30 projects per year, mostly in the building, transport, construction, and information and communications technology (ICT) sectors. Initially, the purpose was to improve project efficiency, with a special focus on cost and delivery, but it was expanded in 2005 to enhance the effectiveness of the investments (i.e., more successful projects in terms of higher benefits for each Norwegian crown spent through, for example, improved cost control and conceptual solutions).

The Ministry of Finance is responsible for the administration of the QA scheme, which in principle, involves a very simple model with only two decision gates. No specific changes to the procedures of the various government agencies are required with respect to, for example, the implementation of the model, project organization, and use of steering groups, PMOs, or project sponsors, thus enabling them to implement their projects as before. Current requirements, however, are somewhat stricter with regard to the planning documents, intended to assure quality and the comprehensiveness of analyses. It is also a requirement that at least two conceptual solutions should be analyzed in addition to the zero option. This is intended to counteract the tendency for path dependency, which has largely characterized established practice. In contrast to previous practice, the documents prepared by the agencies (in some cases by the line ministries) have to be quality assured by external advisors before being submitted for appraisal at the political level. The quality assured are pre-approved private consultants who have framework agreements with the Ministry of Finance. They have a limited mandate that requires them to examine the quality of the documents and not to address the political issues relating to the choice of project. They are also required to perform a separate independent, probability-based, cost estimation and a business case.

Figure 2 shows the roles and principles in investment project governance in Norway. Individual ministries are responsible for new investment initiatives, the vast majority of which are initiated and planned by a subordinate agency. These planning documents are then subjected to external quality assurance on behalf of the relevant line ministry and the Ministry of Finance. The line ministry will summarize the findings and recommendations in a memorandum, which will be submitted to the Cabinet for political appraisal before the matter is presented to Parliament for its approval and final decision.

The State Project Model involves two stages, as shown in Figure 3. The first stage concerns the choice of concept. The agency's pre-study (comprising an

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* NOK 750 million
assessment of needs, alignment with government strategy, the opportunity case, and the business case) is subjected to an external quality assurance of the choice of concept (QA1). At this stage, it will be decided at the central government level whether to reject the project or to move on to the pre-project phase, and in such cases which concept to choose.

At the next stage, when the pre-project has been finalized, the agency has to present an overall project management document, which provides information on, for example, objectives, budgets and target cost, implementation strategy, and contract strategy. This document is then subjected to external quality assurance of the cost estimate and management documentation (QA2). Budgets are based on formal uncertainty analyses and stochastic cost estimation. The recommended budget will commonly be close to the P85 level, and the recommended target cost for the responsible agency is normally lower and close to the P50 level.4

The line ministry and the Ministry of Finance will summarize the quality-assured documents and the recommendations based on them, in a memorandum to the government. Special prominence is then given to the proposed budget; thereafter, the government will submit the matter to Parliament, which will make the final decision and stipulate both the budgeted cost that commits the responsible ministry, and the target cost that commits the agency. Alternatively, Parliament may reject the project at this level.

The Other Case Countries—Establishment and Scope

In common with Norway, the background to the governance schemes in the other five case countries was negative experiences from past projects, especially with regard to cost overruns and delays:

- Like Norway, the United Kingdom was a pioneer. In the year 2000, a separate unit—the Office of Government Commerce (OGC)—was created at HM Treasury, to manage a scheme applying to the largest and riskiest public projects. Initially, it focused on budgets and project management documentation, drawing on experts from the private sector, and a number of follow-up points throughout the project life cycle. The OGC developed a standardized gateway process and public project methodology that came to be widely disseminated. Subsequently, the scheme was strengthened, with focus increasingly being placed on the front-end (a so-called Starting Gate review was introduced), on portfolio management, and on the education of public project leaders. In 2011, a new unit, the Major Projects Authority (MPA), was established, with a stronger mandate, given directly by the Prime Minister, and this unit reports jointly to HM Treasury and the Cabinet Office. In 2016, the MPA merged with Infrastructure UK to form the Infrastructure and Projects Authority (IPA). Preliminary evaluations suggest positive effects of the scheme on project management and cost savings. Main sources for a description of the scheme and experiences are HM Treasury and Cabinet Office (2011) and National Audit Office (2012).
- Denmark, inspired by the United Kingdom and Norway, launched a scheme applying to transport projects, in the wake of a study of cost overruns in 12 transport projects (Ministry of Transport and Building, 2010a, 2010b, 2010c, 2015). A financial management model was established in 2003 to streamline decision-making processes for the various sectors. In 2007, the financial management model

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4With stochastic (probability-based) cost estimation based on either mathematical analytical methods or simulation, the result will be a cumulative probability distribution of the investment cost. P85 implies that the cost will be at or below this level with 85% probability. Similarly, there is a 50% chance that a budget at P50 will be adhered to. The budgeted cost should include a residual reserve and therefore be higher than the expected cost. At the same time, the target cost for the agency should be more ambitious, to give incentives for efficiency and cost control. In Norway, the difference between the budgeted cost and the target cost is kept as a residual reserve, normally on a ministry level.
was expanded, both by requiring projects in excess of US$36 million to be subjected to external quality assurance, and by adding an experience-based correction factor to the cost estimate. Decisions are lifted to the parliamentary level.

- In the Netherlands, each ministry is responsible for its own major projects. In 2008, the Ministry of Infrastructure and the Environment, which has by far the largest portfolio, introduced an integrated investment program, MIRT, which includes a mandatory stage-gate process. The predominant issue to be addressed was how to avoid cost-overruns and speed up the implementation of major infrastructure projects, but also more generally to ensure a robust foundation for major projects, with broad participation from affected parties, commitment at the political level, and the assessment of several alternative conceptual solutions.

- In Quebec, in 2008, the Treasury Board established a political framework for the governance of large public sector investment projects. The scheme was revised and strengthened in 2010, and again in 2014, when it was given in the form of a directive, with increasing focus on the front-end (Secretariat du Conseil du trésor, 2014). The organization of the scheme has been developed and strengthened over time. In 2014, a unit reporting to the Treasury Board, the Société Québécoise des Infrastructures (SQI) was established as the project manager for all major infrastructure projects, in association with the sponsoring line ministry.

- Sweden was the last of the case countries to introduce a governance scheme, which happened in 2012, and only for transport projects (see Trafikverket, 2014). Traditionally, the transport agency has had a rather independent role, but decisions regarding major projects are now lifted up to a government level, as in the other two Scandinavian countries. The decision base for the choice of concept includes assessments of needs and alternative options, and more formalized uncertainty analyses of cost estimates have entered into use in recent years.

The background to and development of the various schemes in the six cases are summarized in Figure 4. It is interesting to observe that several countries have expanded and strengthened their schemes over time, and reorganized the management of them. Generally, the purpose of most of the schemes initially related to the efficiency aspect in the implementation of the projects. Later, a somewhat broader perspective on the front-end and the choice of concept was adopted in Norway, the United Kingdom, the Netherlands and, finally, in Quebec. In Sweden, the requirement for conceptual appraisals as well as environmental assessments

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5 DKK 250 million
6 Main source: Shiferaw (2013).
have long been a key focus. Denmark still has a somewhat narrower focus, but includes economic and transport analyses.

Overview of the Schemes
A detailed comparison of the various governance schemes in the six case countries is presented in Table 1. The findings concerning specific elements of the schemes are discussed separately in the following subsections.

Projects Covered
The United Kingdom, Quebec, and Norway have governance schemes that in principle apply to all sectors where the state is responsible for infrastructure projects (funding, procuring and, in many cases, implementing and operating). The other countries have schemes that only apply to one or some sectors, and certain sectors are exempted, as in Norway.

In all countries, the schemes focus on projects with central government funding that are large, complex, or otherwise involve risk on the part of the central government. Only three countries have introduced a general threshold value defining which projects should be encompassed: Norway, Denmark, and Quebec. A threshold value is a simple criterion for deciding whether a project is subjected to the regime, but its application may seem rigid and not always optimal. This criticism has been leveled against the Norwegian scheme. In the United Kingdom, the Infrastructure and Projects Authority makes an overall assessment as to whether a project should be encompassed by the scheme, and it has chosen to include a considerable number of modernization projects that are “small” in terms of investment cost, but highly complex and innovative, and thus risky.

Parties and Roles
Figure 5 provides an overview of how project governance is organized in the six case countries. The gray boxes imply influence over decisions taken at the various gates in the stage-gate models, with a special focus on the front-end (choice of concept and final approval of the project), and the pattern-filled boxes indicates the quality assurance function.

We find that the government plays a key role as a decision maker in all countries, primarily with regard to the final choice of project alternative. In the Scandinavian countries, the final approval is elevated all the way to the parliamentary level. Presumably, this has to do with these countries being relatively small, but also because they normally have minority governments, and thus need support at the parliamentary level. It may also be noted that many central government-funded investment projects in Scandinavia, especially within transport, are highly politicized, and not viewed exclusively as measures for national economic growth (Boge, 2006).

By contrast, in the United Kingdom and Quebec the Treasury has an important role in advising the government, based more on economic and technical considerations than on political concerns. Klakegg et al. (2015) generally hold that the UK scheme is somewhat more “business-like” than the Norwegian one; it is largely based on best practice in the private sector, and attaches major weight to financial and profitability issues. In the Netherlands, the role of advising the government is performed by an inter-ministerial commission (ICRE) with representatives from the various ministries, and with the Ministry of Finance having a very strong position. It should also be noted (although not shown in Figure 5) that the Dutch scheme involves broad participation of stakeholders in the front-end of public projects in a more systematic manner than those in the other countries—the purpose being to pull discussions toward the front-end and avoid tugs-of-war in later stages.

Most project appraisals are conducted at the agency level in all countries, with their sponsoring line ministries being involved to varying degrees. Quebec stands out in that the new designated government agency, SQI, is responsible for all infrastructure projects across sectors. The quality assurance function is performed by parties independent of those who conduct the appraisals, and these reviewers have a key role in most countries, feeding their advice directly into the decision-making process.

Quality Assurance Reviews
Independent quality assurance reviews are performed in all the countries. In Norway, the use of external experts has been controversial. The criticism is partly that it prevents the development of adequate expertise within the public administration; partly that the consultants do not possess enough sector competence; and partly that when a group of consultants is pre-qualified for such work, it may achieve something akin to a monopoly position. The same kind of criticism is heard in Denmark. In Sweden, where much of the quality assurance takes place on an ad hoc basis and internally within government agencies, the criticism is rather that it becomes difficult to ensure that the quality assurance is sufficiently independent and professional. In the Netherlands, Quebec, and the United Kingdom, designated public bodies are established to perform the quality assurance function. In Quebec, quality assurance is performed both internally in the SQI, and then again by SCT at the Treasury Board before the project is presented to political decision makers.

An important principle of all schemes is that the external quality assurance arrangement only has an indirect impact on the decision-making process. The decisions are to be made at the political level, and the recommendations of the quality assurer have advisory status only.

The Stage-Gate Models
All six countries use stage-gate models in their governance schemes, defining the number of project phases, decision points, and the types of analyses
## Governance of Major Public Investment Projects

<table>
<thead>
<tr>
<th>Criteria/Country</th>
<th>Norway</th>
<th>Denmark</th>
<th>Sweden</th>
<th>The Netherlands</th>
<th>United Kingdom</th>
<th>Quebec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who initiates the QA process?</td>
<td>Ministry of Finance</td>
<td>Ministry of Transport</td>
<td>Agency</td>
<td>A designated government agency</td>
<td>A designated government agency</td>
<td>A designated government agency</td>
</tr>
<tr>
<td>Who decides the choice of concept?</td>
<td>Government</td>
<td>Parliament</td>
<td>Agency or Government</td>
<td>A designated government agency</td>
<td>Treasury</td>
<td>Council of Ministers</td>
</tr>
<tr>
<td>Sectors included$^2$</td>
<td>All, with some exceptions$^3$</td>
<td>Transport sector</td>
<td>Transport sector</td>
<td>Infrastructure projects</td>
<td>All sectors$^4$</td>
<td>Infrastructure projects</td>
</tr>
<tr>
<td>Threshold value (million)</td>
<td>NOK 750</td>
<td>DKK 250</td>
<td>No</td>
<td>No</td>
<td>Large projects$^5$</td>
<td>CAD 50</td>
</tr>
<tr>
<td>Who appraises the project?</td>
<td>Agency or ministry$^6$</td>
<td>Agency</td>
<td>Agency and regional authority</td>
<td>Responsible government agency</td>
<td>Agency or ministry</td>
<td>A designated government agency</td>
</tr>
<tr>
<td>Who performs quality assurance?</td>
<td>External consultants</td>
<td>External consultants</td>
<td>A designated government agency, and internally</td>
<td>A designated government agency</td>
<td>Independent quality assurers$^7$</td>
<td>A designated gov. agency</td>
</tr>
<tr>
<td>Requires co-funding from promoters</td>
<td>No</td>
<td>No</td>
<td>No, but may happen</td>
<td>For all in excess of EUR 60 billion</td>
<td>Desired, but no requirement$^8$</td>
<td>To be considered, not required</td>
</tr>
<tr>
<td>Budgeted cost</td>
<td>P85 (normally)</td>
<td>Basic calculation + 20%$^9$</td>
<td>Basic calculation + 10%</td>
<td>Budget$^{11}$</td>
<td>Estimate plus supplement</td>
<td>Estimate plus supplements$^{10}$</td>
</tr>
<tr>
<td>Target cost</td>
<td>P50 (normally)</td>
<td>Basic calculation + 10%</td>
<td></td>
<td>2</td>
<td>5</td>
<td>Budget</td>
</tr>
<tr>
<td>Decision points</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>QA or advisory interventions</td>
<td>Yes</td>
<td>Yes</td>
<td>Limited</td>
<td>Limited</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Transparency</td>
<td>No</td>
<td>No</td>
<td>Limited</td>
<td>Limited</td>
<td>Limited</td>
<td>Limited</td>
</tr>
<tr>
<td>Portfolio management as part of the scheme</td>
<td>No</td>
<td>No</td>
<td>No, but may happen</td>
<td>For all in excess of EUR 60 billion</td>
<td>Desired, but no requirement$^8$</td>
<td>To be considered, not required</td>
</tr>
</tbody>
</table>

### Notes:

1. Concerns approval of business case; the line ministry may have determined the choice of concept much earlier.
2. Some countries may have different schemes in some sectors.
3. All, except for health, oil/gas, and state enterprises.
5. No threshold value; relevant factors are size, complexity, requirement for a separate statute, and the degree of innovation.
6. External resources are drawn on in some cases, from the private or public sector, including QA resources.
7. Both private and public sector technical experts.
8. This varies between sectors.
9. The 20% supplement is managed at the portfolio level and is transferable from one year to the next.
10. The government should be informed if it is anticipated that the budget will be overrun.
11. Recently based on stochastic cost estimation (P50).

**Table 1:** A comparison of the governance schemes in six countries.
Figure 5: Responsibility for appraisal/quality assurance and decisions under the various governance schemes in six countries.²

²ICRE, inter-ministerial commission for improvement of the structure of the economy in the Netherlands; CPB, Netherlands Bureau for Economic Policy Analysis; PBL, Netherlands Environmental Assessment Agency; SCT, Secretariat du Conseil du trésor; SQI, Société Québécoise des Infrastructures; IPA, Infrastructure and Projects Authority.
Figure 6: Summarized versions of the six stage-gate models.

IAAP is an integrated assurance and approval plan.
and independent reviews required at the various stages. The number and names of the phases are more or less the same in all countries, but we find larger variation in the number and locations of reviews and decision points, as shown in Figure 6. The Scandinavian countries are distinguished by formal decision points and quality assurance being limited to the front-end phase, whereas the other three countries have follow-up points during project implementation and closure, and in the United Kingdom, for some projects all the way into the operational phase.

As far as the number of decision points is concerned, Denmark and Norway have the simplest schemes, with only two decision points. With regard to quality assurance, the Netherlands have the simplest arrangement, with only one review. Quebec and the United Kingdom have the largest number of decision gates. The UK scheme is the most comprehensive, involving the most detailed control measures and requiring the preparation of a separate plan for the subsequent follow-up and quality assurance of each project. However, the UK model is also flexible in the sense that the number of intervention points and their scopes are decided on a project-by-project basis and may be changed throughout the project.

It should also be noted that the scope of a review varies. The reviews in the Norwegian scheme are rather time consuming, inasmuch as the quality assurer is required to perform his or her own independent analyses, and not only oversee the work that has been done. By contrast, in the UK scheme, the number of checkpoints is large, but each quality assurance exercise is slightly simpler.

In Norway, the first decision point concerns the choice of concept, after the pre-study phase. In recent years, some of the other countries have introduced a formal decision gate at an even earlier stage. In the United Kingdom, for example, the Starting Gate review process was introduced in 2011, clarifying the strategic premises underpinning the choice of alternative concepts, but not involving technical analyses of specified alternatives at this stage. The first stage of the business case is not a detailed appraisal of alternatives, but rather a rough analysis, with the purpose of reducing the opportunity space from a long list to three or four alternatives. Similarly, the Dutch scheme is strongly focused on early assessment of solutions to a problem and broad involvement of stakeholders. This is an interesting observation, as it is generally appreciated that premises laid down at this stage may have a decisive impact on the actual choice of concept. In Norway, early experiences indicate that at the QA1 stage many premises are already laid down and some stakeholders have high expectations related to a specific solution. In such cases, we may see that the pre-study includes alternatives that are variants of the same concept rather than truly different solutions.

**Cost Estimation**

As far as cost control is concerned, a key element of the Norwegian governance scheme has been the introduction of a *budgeted cost* and a distinct, lower *target cost* for the agency. The difference between the two figures is the contingency reserve, which is normally controlled by the line ministry. The figures are based on probability-based cost estimation (using the “successive principle”) and are reviewed by external consultants who will normally recommend a budgeted cost at or close to P85, and a target cost at P50. Parliament’s decision normally follows the recommended figures.

Norway and, recently, Sweden too are apparently alone in using probability-based estimation in each project. Denmark has an advanced system and methods for cost estimation, including an extensive cost database, but a basic cost estimate is applied, to which is added a general supplement of 10% for the agency and 20% for the ministry. The 20% supplement is thus available at the portfolio level, and is transferable from one year to the next. Hence, the latter provides the ministry with somewhat more freedom of action than under the Norwegian scheme. In the United Kingdom, there does not seem to be a distinction made between target cost and budgeted cost, but an uncertainty level is chosen for each case (e.g., P50 if central government is willing to assume a high risk of cost overruns or if the project forms part of a large portfolio) and optimism bias correction factors are used, based on rules of thumb tailored to the chosen uncertainty level. The other countries apply a budget that has to be adhered to, but may add a notional supplement that is not to be exceeded; however, if this does happen, the government must be informed.

We have not been able to address specifically the experiences of individual countries with the various budget estimation principles in this study, but this would be an interesting issue for potential follow-up. Lessons from the Norwegian model thus far indicate that projects under the scheme are now largely completed within their cost frames (Volden & Samset, 2017). The deviation between the final cost and the target cost is almost symmetrically distributed around the median. Hence, at the portfolio level, the government is able to control the cost of major investment projects more effectively. Whether this can be explained by the use of stochastic estimation, thorough external quality assurance, or the practice of establishing a lower target cost for the agency, or a combination of these, remains to be proved.

**Co-Funding Requirement**

In all six countries, the governance schemes are applicable to projects with central government funding; however, they are often initiated locally and benefit specific groups or regions, thus giving rise to perverse incentives (Volden & Samset, 2015). The conditions attached to such funding differ between the countries. The Scandinavian countries...
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stand out in that generally they do not require co-funding from those who will benefit from the projects. The exception is the road sector in Norway, where a significant element of user charges has been introduced in recent years. The Netherlands is distinguished by requiring co-funding from local authorities who come forward with a project proposal. The rationale is that this signals commitment and a willingness to pay, which increases the likelihood that the project idea is feasible. There is also a requirement that all investment initiatives in excess of EUR 60 million (approximately US$64 million) have private co-funding. The rationale is that this will result in more weight being attached to long-term revenue flows (in the form of user fees) as well as efficient project implementation. In the United Kingdom and Quebec, the central government has signaled a desire for co-funding from local authorities and the private sector in certain areas, although there is no requirement.

Transparency

Transparency is a key criterion for defining good governance. As noted by Klakegg and Volden (2016), the public sector depends on transparency as a means of strengthening accountability, where the private sector has competition. In major public projects, it is a question of ensuring that the decision-making processes and administrative processes are well documented. There is also a prerequisite for another governance principle—participation—in order to give stakeholders and the general public an opportunity to express their views in the process.

The Norwegian scheme attaches great importance to transparency. The Ministry of Finance currently funds a research program to follow the scheme closely and collect information about the projects. All QA reports are published on the program’s website.

involved, including the reviewers, put a lot of effort into their work and has resulted in high-quality plans and estimates. Furthermore, as the projects are finalized and enter their operational phases, cost figures and other project results are made available to the public.

None of the other countries seems to practice the same level of transparency as Norway, although several of them have expressed a concern for this matter. In the United Kingdom, the IPA publishes valuable information about major projects in its annual reports, although most of the data are on the group level and published with a considerable time lag. Preliminary evaluations of the UK scheme recommend that more data be published earlier and at the project level. In other countries, there is hardly any publicly available information about the projects.

The Portfolio Perspective

The Norwegian governance scheme focuses on requirements applicable to individual projects, and does not impose explicit portfolio evaluation requirements. The same is essentially the case for the schemes in all other Scandinavian countries. Nonetheless, it must be expected that the high level of transparency will make it easier for the line ministries to make decisions from a portfolio perspective. It must also be expected that overall project risk and the need for a contingency reserve will be influenced by whether or not the project forms part of a larger portfolio.

In the Netherlands, the MIRT program was introduced along with the requirements applying to the individual projects. The intention was to ensure coherence and synergy and to facilitate portfolio management within the Ministry of Infrastructure and the Environment. The UK and Quebecian schemes are also intended to include a portfolio perspective, inasmuch as a central government unit is responsible for compiling data on all infrastructure projects in the portfolio, thus making it possible to analyze and manage them collectively.

These units are also responsible for training and facilitating learning across sectors; thus, both the IPA (United Kingdom) and, to some extent, the SQI (Quebec) have similarities with an organization’s strategic PMO, although in this case working on the central government level. It should also be noted that in the United Kingdom, quality assurance is to be performed not only on individual projects but also at the program and portfolio levels at regular intervals. However, there is much to suggest that this potential has not yet been realized.

Assessments and Conclusions

A number of international studies have highlighted the problems of managing public investment projects with respect to operational, tactical, and strategic aspects. Special measures are therefore required to ensure successful implementation and outcomes. Norway was a pioneer and, in the year 2000, introduced an overarching governance framework for major public projects. The framework and its effects, some of which are very encouraging, have already been presented in earlier literature. In recent years, a number of countries have introduced similar frameworks in which independent quality assurance is duly coordinated with the decision points. Six schemes are presented and compared in this study.

We found that the six governance schemes have many characteristics in common. They were all established for project governance by central government, and they apply to large projects that involve particularly high costs, risk, and complexity, or that are highly innovative. They all apply a stage-gate model at the project level, with clearly defined roles and responsibilities, including independent quality assurance reviews of project documentation at specified decision points. They also have measures to avoid optimism bias in the cost estimates, and they place key decisions, as well as responsibility, for managing the scheme at a high level in the system.

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Overall, the schemes seem to be fairly consistent with the recommendations from the literature; some exceptions are that only the Netherlands require co-funding from beneficiaries to obtain state funding, and only Norway highlights transparency at the project level. Furthermore, there is potential for improvement in several countries when it comes to integrating the portfolio perspective. The various schemes’ emphases vary somewhat, but we have observed a general development over time toward more focus on the front-end and the choice of concept. This is in line with general development within the project management community (Morris, 2013). All six countries now require needs assessments and the evaluation of alternative conceptual solutions, which demonstrates that their importance is duly acknowledged.

At the same time, we know that the final project choice is not only the result of systematic investigation of alternatives by professionals and experts. In many cases, the politicians’ priorities carry more weight, and this needs to be tolerated within a democratic political system. It is nevertheless essential in a project governance scheme to bring in technical and economic expertise at an early stage in order to identify and, if possible, eliminate the worst alternatives or conceptual solutions. Within a political reality, there is no guarantee that the best alternative will be chosen, but we can possibly avoid the worst ones. To quote Herbert Simon (1976), in many cases the realistic scenario would be not to aim for “maximizing,” but to put the bar at “satisficing.”

There are a number of significant differences between the six schemes, such as in the use of internal or external experts, in the demarcation between the political and technical spheres, and in the comprehensiveness of the schemes, the organization of the schemes, and the extent to which projects are assessed individually or as part of a public project portfolio. Some of the differences can probably be explained by historical and cultural differences, such as the Scandinavian countries’ involvement of Parliament in the approval of individual projects. However, both Norway’s and Denmark’s use of private consultants as opposed to the United Kingdom’s and Quebec’s use of a government unit, is not what might be expected (cf., the Nordic “strong state” tradition versus the Anglo/ American market orientation). All in all, we are faced with two main types of project governance schemes: the schemes in the Scandinavian countries and the other schemes. The former are relatively simple in terms of the number of intervention points, although these may be comprehensive in terms of which analyses are to be performed. The schemes do not intervene significantly in existing processes and practices, but impose new qualitative requirements with regard to appraisal and documentation. The schemes in the three other countries are more ambitious and extensive, with more follow-up points, also during the implementation phase. With regard to Williams et al’s (2010) distinction between governance of and governance through projects, it might be claimed that whereas the Scandinavian schemes are only about governance through projects, the other schemes are also about governance of projects. The United Kingdom and Quebec have altered the organization of their schemes several times, and now have centrally placed units with a clear mandate to managing the quality assurance function, as well as responsibility for the support and development of expertise, and compiling and publishing data on the portfolio level. In Quebec, a central organization is even mandated to serve as project manager for all major infrastructure projects.

The Norwegian scheme currently aims to achieve control over costs and progress, and also to ensure that investments deliver economic benefits. The scheme is intended to have a disciplining effect, both on the agents responsible for the projects and on their sponsoring ministries. The impact on cost control seems quite satisfactory (Volden & Samset, 2017). However, we need more knowledge about the effects of the various measures, such as the use of probability-based estimation, the role of private sector reviewers, the use of a lower target cost for the agency, and the focus on increased transparency. There are also objections relating to, for example, time and resource use, how the use of private consultants prevents the development of central government expertise, and the scheme being rigid and inflexible. It has also been argued that QA1 takes place too late and that the analysis of alternatives may turn into more of a ritual exercise than a forceful tool used to identify the best conceptual solution. In this regard, it would be useful to learn more about the experiences obtained with interventions at an earlier stage in other countries, such as Starting Gate reviews in the United Kingdom.

The schemes described in this article were all introduced in recent years and have not been in operation sufficiently long for any conclusions to be drawn as to their effects. The ultimate question is whether some schemes are more effective than others in improving project delivery as well as outcome, and to what extent an effective scheme can be applied also in other countries. This will be a topic for future research. The fact that there are several different governance schemes in operation is positive, and they might inspire alternative ways of organizing and implementing such schemes in the future. It should be noted that we have focused only on the top layer of project governance introduced by central government, assuming that the governance arrangements at the level below (e.g., line ministry, department, and agency) are in place to ensure tactical and operational project success. A topic for future research could be to address the question of whether the rather simple schemes in the Scandinavian countries are matched by the necessary requirements, guidelines, and training on the lower levels. Furthermore, we have only looked at the structural elements of a project governance scheme. Future research should
also seek to determine how these work together with the relationship-based elements on different levels of government.

A further hypothesis, which is perhaps too difficult to test, relates to the trickle-down effects, if any. This concerns whether improvements in project governance and governmentality on other levels and for smaller projects can be attributed to the overarching schemes discussed in this article. To date, the indications from the Norwegian scheme are that the spinoffs may be considerable, not only in the public sector but also among the external quality assurers, project management consultants, contractors, and suppliers, and in the research community.

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