This is to certify that the
dissertation entitled

IMPACT OF INVENTION-TO-IMPLEMENTATION DISTANCE ON MANUFACTURING PROCESS IMPLEMENTATION PERFORMANCE: DOES THE IMPLEMENTATION TEAM'S ABILITY TO LEARN MATTER?

presented by

TEMYOS PANDEJPONG

has been accepted towards fulfillment
of the requirements for the

DOCTORAL degree in MARKETING AND SUPPLY CHAIN MANAGEMENT

Morgan Swink
Major Professor's Signature

6/12/07
Date

IMPACT OF INVENTION-TO-IMPLEMENTATION DISTANCE ON MANUFACTURING PROCESS IMPLEMENTATION PERFORMANCE: DOES THE IMPLEMENTATION TEAM'S ABILITY TO LEARN MATTER?

By

Temyos Pandejpong

A DISSERTATION

Submitted to
Michigan State University
In partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Marketing and Supply Chain Management

2007

ABSTRACT

IMPACT OF INVENTION-TO-IMPLEMENTATION DISTANCE ON MANUFACTURING PROCESS IMPLEMENTATION PERFORMANCE: DOES THE IMPLEMENTATION TEAM'S ABILITY TO LEARN MATTER?

By

Temyos Pandejpong

This study investigates factors that affect a manufacturing process innovation (MPI) implementation project performance. It empirically examines the effect of the invention-to-implementation distance (IID) on MPI implementation performance. Three types of IID included in this study are physical, temporal and organizational distance. This study develops a conceptual framework of the MPI implementation process as a project management task involving learning and knowledge-creating that requires absorptive capacity. The primary hypotheses are that distance has a negative effect on implementation performance, and that the effect is moderated by the level of technical competence, functional diversity and psychological safety of the implementation team. A cross-sectional survey methodology is employed to test the hypotheses of the conceptual framework. The results indicate that organizational IID is the only IID associated with lower MPI implementation performance. Technical competence, functional diversity and psychological safety each has a direct positive effect on a different type of implementation performance. Some interaction effects between IID and absorptive capacity are significantly positive. The results are discussed in light of their theoretical contributions.

Dedicated to my parents, Arn and Sawanee Pandejpong.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank Dr. Morgan Swink. As the chair of my dissertation and my mentor for the last 4 years, Dr. Swink has been encouraging throughout the whole process. I leave Michigan State University with the highest respect for Dr. Swink's achievements and dedication to the field of Operations Management.

I also thank my other committee members: Dr. Roger Calantone, Dr. Ram Narasimhan, and Dr. Gary Ragatz. Dr. Calantone and Dr. Ragatz's laid-back style and perceptive comments and questions were appreciated throughout the dissertation process. Dr. Narasimhan has had multiple positive influences on me throughout the program both in classrooms and outside.

This research would have been impossible without the cooperation of the respondents and the funding. I truly appreciate the demands placed upon managers and executives in taking the time to complete the questionnaires. I also thank Dr. Robert Nason and Dr. Swink for sponsoring the project.

I would be remiss if I did not also thank the rest of the faculty in the department for their encouragement and support since my first day of the doctoral program. I also thank the departmental staff for their warm personalities and willingness to always assist me.

Finally, in closing, I thank my friends and family for making me the person I am. My brother, Toryos, and sister, Denla, have always set good examples for me to follow. My parents, Arn and Sawanee, are owed a huge debt of gratitude for their support in both academic and non-academic efforts throughout my life.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1 Introduction

This chapter presents the motivations for conducting this dissertation. It ends with definitions of terms used in this study, the research questions and overview of the dissertation.

1.1 Motivations

The resource-based view (RBV) of the firm has recognized that competitive advantages stem from proprietary resources and capabilities (Barney 1991; Prahalad and Hamel 1995). Arguably however, no asset can yield competitive advantage forever. Market changes, imitations, and substitutions constantly reduce the value of a company's asset. Companies need to engage in a continual effort to change and differentiate themselves. Recently, scholars turned their attention to this ability to change existing resources and capabilities and referred to them collectively as dynamic capabilities (Teece et al. 1997; Eisenhardt and Martin 2000; Zollo and Winter 2002). One very important dynamic capability is the ability to innovate (Eisenhardt and Martin 2000).

While innovation has always been an important factor in business competition, management researchers have only given significant attention to innovation in the last few decades. Social science researchers in a number of fields, on the other hand, have studied innovations from various perspectives for the last two centuries. Sociology and economics, for examples, have long recognized the importance of innovations as agents of social changes and economic growth (Sundbo 1999). Their focus has been to understand how innovations create changes in the society and the economy, as well as how socio-economic conditions influence the rate and quality of innovations, e.g., (Sedgley and Elmslie 2001; Albino et al. 2006; Choudhury et al. 2006; Sinha 2006)

Different management disciplines have recognized the value of innovations, and have focused on different related areas.

- Early strategic management and marketing research focus on how and what type of innovation can be used to competitively position the company in the market. Innovation is viewed merely as another corporate factor of production (Sundbo 1999).
- Organization behavior and Psychology attempt to identify interactions of personnel at the micro level and how factors such as culture affect innovativeness within firms (Anderson et al. 2004).
- Accounting tries to understand effects of different type of accounting systems (e.g., costing systems) on rate of innovation, efficiency and profitability (Drake et al. 1999; Drake et al. 2001).

While significance of innovations to companies as well as a broader social/economic system are clearly recognized in these fields, the focus of these fields is primarily on the impact and benefits of innovation. The innovation process, therefore, has mostly been taken as a black box.

Operations Management (OM) research, on the other hand, concerns itself with the task of improving efficiency and effectiveness of the innovation process. In order to improve the process, OM researchers, therefore, necessarily need to investigate at the resource level. Here resources refer broadly to both physical and non-physical assets that an organization employs for the innovation process. The OM question can then be summarized as: what factors are important in successfully managing the innovation process?

Early OM research on innovation, however, has focused on new product development. This was because product innovations were observable to everyone and perceived to be more advantageous than process innovation (Damanpour and Gopalakrishnan 2001). Research in operational process innovation, on the other hand, has been less prolific. However, there is a growing recognition among both practitioners and academics that operational (e.g., manufacturing) processes can be leveraged for competitive advantage (Skinner 1969; Hayes and Wheelwright 1984). Zahra and Das (1993) argue that "although US companies have excelled in developing new products, successful Japanese and German manufacturers have stressed process innovations in their bids for world leadership." This has generated greater attention to manufacturing process innovation (MPI). In this study the term MPI will refer to the set of activities aimed at both developing and putting new manufacturing process ideas into effect (Schroeder et al. 1989; Bamberger 1991).

Reasons for heightened awareness of the importance of MPIs include increasing complexity of products requiring more sophisticated production systems (Jayanthi and Sinha 1998); and maturity of many products shifting competitive arena to process improvement (Abernathy and Utterback 1978; Pisano 1997). At the industry level Abernathy and Utterback (1978) observes more emphasis on product innovation in the first 'fluid phase', an emphasis on process innovation in the 'transitional phase', and a balanced level of incremental product and process improvements in the final 'specific phase'. As more products mature in the last decade into 'specific phase', attention shifts back to process innovation.

In addition to easily seen benefits of enhancing operational competences (cost, quality, delivery, and flexibility), other benefits of MPIs include strong proprietary position through first mover advantage (Pisano 1997) and market reputation through an image of a company committed to excellence (Pisano 1997; Dutta et al. 1999).

There are two main categories of research on MPI. First is research that focuses on Japanese-derived practices. The success of Japanese companies in the last three decades, particularly in the automotive industry, has spawned interests in their management approaches (e.g., Spear and Bowen (1999)). The influence reflects in what we know today as Just-In-Time (JIT), Total Quality Management (TQM), Six-sigma, and continuous improvement programs, for examples. Examples of MPIs that arise from these programs include projects to reduce machine setup time and employing of production signaling technique such as kanban. These MPIs can be characterized as incremental improvements that are internally originated.

A few researchers have investigated success factors of overall JIT and TQM programs (e.g., Flynn et al. 1995; McLachlin 2004; Salahedin 2005) , but not at the individual project level. Thus the success factors investigated are at the company or plant level and not at the project level. Moreover, while the success of a major program is necessarily an accumulation of success at small individual project levels, the magnitude of these programs make it difficult to pinpoint which factors are more influential at the individual project level.

The second stream of research focuses on implementation of a particular class of innovations such as advanced manufacturing technology (AMT) (Small and Yasin 1997; Burcher et al. 1999; McDermott and Stock 1999). While this set of studies focus at the individual project, the focus on a single technology makes generalizability of their results to other types of process innovations limited.

This study focuses implementations, a latter stage in MPIs, where an invention is incorporated into an existing operational system. This line of research is important for two reasons. First, Tyre and Orlikowski (1993; 1994) find that operational process implementation activities are critical in determining an organization's ability to realize an innovation's potential. The implementation period is when modifications of the technology and the organization itself are easiest and provide greatest value to the organization. The reasons include that patterns of innovation use become rigid and difficult to change, expectations of employees are adjusted with their experience resulting in little motivation to make subsequent changes, and team membership and enthusiasm erode over time (Tyre and Orlikowski 1994).

Second, process implementations are difficult and are main causes for companies not being able to achieve intended benefits of innovation adoptions (Klein and Sorra 1996; Waterson et al. 1999; Edmondson et al. 2001). Waterson et al. (1999) report that less than 50% of the companies in their sample thought that the implementation of new manufacturing practice has more than moderately met their objectives. A reason is that a successful implementation of process innovations depends on widespread changes in organizational structure and administrative systems (Ettlie and Reza 1992; Damanpour 1996). Changes required in process innovations, i.e., implementing a manufacturing practice new to the organization, include upgrading of individual skills, redesigning of individual tasks, restructuring of control, rewards and information flows (Shani et al. 1992) and even workforce composition (Frohlich and Dixon 1999). In addition, Frohlich and Dixon (1999) find a considerable gap between managerial beliefs and empirical findings about what is important in implementing advanced manufacturing technology (AMT), suggesting that practitioners do not have a clear idea of how to effectively implement MPIs.

According to Kazanjian and Drazin (1986) one of the biggest challenges in process innovation is "how to best implement these technologies in ongoing work settings". Design engineers can never fully anticipate the effects of small changes in materials, surroundings, and procedures (Khurana 1999). Macher and Mowery (2003) also note:

> "a common problem associated with new process development is the hand-off of a new process technology from development to the production facility. Manufacturability issues often appear only after a new process has been transferred to the manufacturing facility from a development site because of differences between the development and production facilities in equipment, production volumes, worker skills, and numerous other factors."

Accordingly, this study will focus on the implementation of MPI. Specifically, this dissertation focuses on the impact of the distance/separation between MPI sources and the adopting organization on the performance of the implementation process. In this study, this separation will be referred to as invention-to-implementation distance (IID). Recently, outsourcing and offshoring of production technology R&D[1] (Baines et al. 1999; Kimzey and Kurokawa 2002; Lewin and Peeters 2006) and adoption of observed best practices (Pilkington 1998; Davies and Kochhar 2000) are becoming more prevalent. While there are benefits associated with these practices (e.g., better design capability, focus on core competency) (Baines et al. 1999; Vanhaverbeke et al. 2002), they also separate innovation implementing units from invention sources. This separation can potentially have negative consequences on how successful an implementation of an MPI will be. This is due to the lack of consideration of the recipient during the invention process (Sen and Rubenstein 1989) and resistance of the adopting organization referred to as not-invented-here syndrome (Katz and Allen 1988; Damanpour 1996; Edmondson 2003).

While the potential negative effect is intuitive, opposing findings also exist. Menon and Pfeffer (2003) find that organizations tend to value external knowledge more highly than internal knowledge. This is due to fear of internal competition and lack of access to scrutinize external knowledge. Thus, employees can be less motivated or even resist an effort to implement MPIs that

---

[1] A recent research by Booz Allen Hamilton and INSEAD surveying 186 of the world's biggest corporations shows that 77% of R&D facilities of major companies that will go up in the next three years will be located in either China or India (Engardio, P. (2006). R&D offshoring: Is it working?, Business Week Online.).

are invented internally. This opposing evident warrants direct testing of the relationship between IID and MPI implementation performance.

1.2 Definitions

It is useful to first define the scope of this study by providing precise definitions of the terms that will be used in this study. The terms implementation, implementation team, implementation performance/success, and (IID) will be defined to provide a shared understanding. The rest of the terms will be defined as they are introduced.

The term innovation has been used to refer to many things. Bamberger (1991) identified different processes that have been referred to as innovation. These include invention, adoption/implementation, and diffusion. Invention is the process where technical specifications (e.g., processing speed and quality) and requirements (e.g., technology, particular skills and materials) are determined. The focus in this study is the implementation process. Following Bamberger (1991), implementation refers to the process that causes an invention to become part of the system. This process includes "all events and actions pertaining to modification of both the [invention] and the organization, the initial utilization, and the continued use of the innovation until it becomes a routine feature of the organization" (Damanpour 1996). Thus, modifications of the practice/technology after overall technical specifications and requirements have been determined are part of the implementation effort and not invention. Defining the terms this way limits invention activities only as activities prior to the implementation stage.

In this study a new manufacturing practice/technology that is implemented refers to a wide range of things. It can be as small as a procedural change, an equipment change, or as large as an automation of a process. A new manufacturing practice/technology can also be an invention of the implementing unit, corporate support functions, or completely external sources (e.g., adoption of new procedures, and purchase of new equipment).

This study takes Leonard-Barton's (1988) perspective that misalignments between new technology and the organization necessarily occur in technology implementation because the invention process can never anticipate all possible problems, and because an aim of many innovation implementations is to stimulate changes. Innovation implementation is, thus, a mutual adaptation process, where both the technology and organization characteristics need to be adjusted to correct for misalignments. Sen and Rubenstein (1989) point out some specific events and actions in innovation implementation. These include planning and carrying out of modifications to the adopted technology and existing practices and infrastructures, garnering of skilled personnel, training of intended users, and making available infrastructure and resources. The implementation process ends when an innovation-adopting organization works with its own manpower, skills and resources (Sen and Rubenstein 1989).

Implementation team in this study refers to everyone who is involved in reinventing/modifying the new technology/practice, deciding which existing routines (procedures regularly followed) and practices need to be changed and how to change them (including conducting pilot tests), and providing support (e.g., technical, infrastructure, finance and training) in institutionalizing new routines. Modification of technology/practice requires the team to understand the mechanics and logic behind the new process (Edmondson 1999; Baer and Frese 2003; Edmondson 2003). In some cases the team may have to investigate existing practices and relationships in their own organization to understand how the new process will link with the rest of the system (Beatty 1992; Pisano 1997). As problems and conflicts can arise at any point, another important task of this team is solving problems (Edmondson 1999; Baer and Frese 2003; Edmondson 2003). In summary, relevant activities in this team include learning, making changes and solving problems as they arise.

Implementation performance or implementation success has been defined in the organization literature as “the incorporation or routine use of a technology on an ongoing basis in an organization” (Edmondson et al. 2001). As an operations management study, efficiency and effectiveness of the implementation process are key concerns in this study. Thus, an implementation is judged to be successful if it achieves technical/operational improvements potential of the invention (e.g., reduced production cost, and enhanced manufacturing quality, reliability, speed of delivery, safety, and environmental friendliness), and the implementation process is executed quickly and economically relative to an organization’s expectation. These three broad areas of success have also been the staples of success measures in the project management literature (Shenhar et al. 2002).

Invention-to-implementation distance (IID) refers to the degree of separation between invention sources and the adopting organizational unit. An invention source is where the implementing unit acquires new practice/technology. An invention could be an idea for procedural change, or a new equipment. Studies of teams have associated physical distance (both in meters/feet and perceptual measures) with separation that prevents communication and collaboration (Hoegl and Proserpio 2004). This study proposes two additional dimensions of separation: temporal distance and organizational distance. Temporal distance refers to elapsed time since the invention occurred. Organizational distance refers to separation created by organizational boundaries.

At one extreme, an invention might be designed at the plant, at the time of the implementation, and solely by members of the implementing unit. This results in no physical, temporal or organizational distance. At the other extreme, an invention might come from a source that is located far away (e.g., an oversea OEM), had been designed for many years, and was purchased off-the-shelf. This results in high physical, temporal and organizational distance.

An important condition of this definition is that an adopted innovation can have multiple sources. The implication on measurement of the construct is that questionnaire items will need to reflect the need to collect information for IID from more than one invention source.

1.3 Research questions

This study builds on earlier technology implementation research from both operations management and organization literature. Findings and theories from project management, organizational learning and absorptive capacity will also be used to explain the hypotheses.

Two specific questions in this study are:

- Does greater IID result in lower implementation performance in terms of achievement of technical objectives, implementation budget and implementation schedule?
- Do project team members' technical competence, team functional diversity and psychological safety, which contribute to learning potential of the implementing team, moderate the effect of IID on implementation performance?

1.4 Overview of the dissertation

The remainder of the dissertation is structured as follows. Chapter II discusses previous findings on variables of interest to this study from technology implementation, project management and absorptive capacity literature. Chapter III discusses the theoretical framework and hypotheses. Chapter IV proposes the methodology to be used in this study. Finally, Chapter V concludes the dissertation with discussion of theoretical contributions, managerial implications and potential future extensions.

Chapter 2 Literature Review

This chapter reviews three relevant sets of literature: technology implementation literature, project management and absorptive capacity and organizational learning. Section 2.1 points out key characteristics of the three streams of literature and their relevance to this study, and Section 2.2 categorizes and discusses past findings.

2.1 Key Characteristics of the literature

First, there are two sets of literature specifically on innovation implementation: those that originate in operations management and industrial engineering and those that originate in organization theories. Repenning and Sterman (2002) offers an insight on the distinction between studies from the two fields: "Whereas theories originating in operations management and industrial engineering largely ignore the beliefs and behaviors of those working with the production technology, organizational theories generally do not account for the physical structure of the organization and its processes." Integration of the two streams of research should foster greater understanding of innovation implementation process. It is an intention of this study to also provide a step forward in bringing considerations of the two fields together.

The second group of literature relevant to this study is Project Management. The literature suggests that manufacturing process innovation implementations are often managed as projects which are one-time events managed by temporary teams (Ettlie and Reifeis 1987; Klein and Sorra 1996). From its start in the 1950's as mathematical research on computer application and expert systems for project planning, control, and risk analysis, project management's focus has recently shifted to identifying factors, such as characteristics of the team, that influence project success or failure (Jugdev 2004). This stream of literature suggests that project success is associated with the existence of several critical implementation factors which are often contingent on specific project characteristics (Pinto and Mantel 1990; Shenhar 2001).

Lastly, the literature on absorptive capacity and organizational learning is reviewed. Process implementation requires an organization to learn new processes and solve problems that arise. Learning in implementation encompasses both technical knowledge (know how) as well as social knowledge (who knows what) (Edmondson et al. 2001). In addition to learning, the implementation team also needs to address discrepancies between existing and required practices by ways of making adjustments to existing practices (e.g., manufacturing routines/procedures and production and service tools and equipment) (Edmondson et al. 2001). Since organizational practices are manifestations of knowledge, modification to them is a form of knowledge creation, the act of combining information and knowledge into new knowledge (Smith et al. 2005).

Citing previous studies (Bradshaw et al. 1983; Simon 1985) Cohen and Levinthal (1990) state that learning and knowledge creation are very similar in their modes of development and necessary preconditions. They group the two concepts under the umbrella of absorptive capacity. Absorptive capacity is defined as "a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability" (Zahra and George 2002). This set of literature examines and points out conditions that facilitate organizations' ability to learn and create new knowledge. These conditions include greater overall knowledge of team members, diversity of the team, and strong networks among team members.

2.2 Past findings on implementation success factors

Four categories of factors that influence implementation success emerge from the review of the aforementioned literatures: 1.) project personnel, 2.) implementation policies and organization, 3.) adopting organization's characteristics and 4.) innovation characteristics. Table 2.1 summarizes variables that have been studied by past studies. The following subsections summarize findings and arguments on each group of characteristics. It is important to recognize that variables in different categories are related and interact and may not be as mutually exclusive as presented here.

2.2.1 Project personnel

Previous studies identify many roles and characteristics of project personnel as success factors of implementations. Project personnel issues include issues involving project leader, team members, and team characteristics.

Project leaders have roles within the project team as well as roles as an interface to the rest of the organization. Roles within the project team include getting the team to work by way of motivation, coordinate and assign tasks to member, facilitate discussions, resolve conflicts and provide guiding visions

(Fedor et al. 2003). From the organizational learning perspective, project leaders are also in the position to foster the learning orientation among team members (Edmondson 1999; Edmondson 2003). These include being inspirational, soliciting inputs and communicating the appreciation of members' skills. Roles with the rest of the organization include garnering of resources and protecting the project from outside influences (Co et al. 1998).

In order to carry out the roles and responsibilities mentioned above, project leaders should possess certain personal characteristics and skills. As benefits do not come instantaneously, and there often are short-term drops in performance (Repenning 2002; Repenning and Sterman 2002; Klein and Knight 2005), project leaders need to be patient and persistent (Beatty 1992). Kerzner (1987) and Hewitt (1995) identified that managers who are results-oriented and pragmatism are more successful in managing projects.

In order to garner resources project leaders need to be politically well established and have a good understanding of the organization (Kerzner 1987; Co et al. 1998). Co et al. (1998) find that projects with politically well established leaders in the company are more likely to be successful. Some important skills include technical and analytical skills (Beatty 1992; Belassi and Tukel 1996), and strong interpersonal skills such as communication, persuasion and motivation (Kerzner 1987; Beatty 1992; Hewitt 1995; Belassi and Tukel 1996). Beatty (1992), however, finds that technically skilled subordinates can make up for the project leader's lack of technical skills.

Team members play an important role in bringing knowledge from external sources and creating solutions to problems the team faces. Absorptive capacity of an organization depends on its members' individual absorptive capacity and the composition of the organization. Individual absorptive capacity in turn depends on their depth and breadth of knowledge, their network outside of the team, and their ability to transfer knowledge to the rest of the team (Leonard-Barton 1988; Cohen and Levinthal 1990; Smith et al. 2005).

Findings from psychology indicate that accumulation of prior knowledge of an individual increases absorptive capacity. The depth of knowledge in one field increases ability of an individual to understand and utilize knowledge from a source, while the breadth and diversity of knowledge (including 'who knows what' or 'who can help') increases the prospect that incoming information will relate to what is already known (Cohen and Levinthal 1990).

Smith et al. (2005) find that years of formal education is a measure of knowledge stocks that is positively associated with the ability of an organization to create new knowledge (knowledge creation capability, KCC). Years of experience, however, was found to have a non-significant negative effect on KCC. This may suggest a tradeoff between expertise and unwillingness to change.

Table 2.1: Literature review summary

Variables	Theoretical Bases			
	Innovation Implementation		Project Management	Absorptive Capacity and Knowledge Management
	Operations Management	Organization		
Project personnel				
Leaders				
strong technical and analytical skills (or supplemented by skilled subordinates)	Beatty (1992)		Belassi and Tukel (1996)	
communication, motivation and persuasion skills	Beatty (1992), Hewitt (1995); Sarin and McDermott (2003)	Repenning (2002); Edmondson (2003)		Fedor et al (2003)
politically well established	Co et al (1998)			
patient for results	Beatty (1992)	Repenning (2002); Repenning and Sterman (2002)		
practical/result-oriented			Kerzner (1987), Belassi and Tukel (1996)	
Team members				
overall technical competence	Hewitt (1995)			Cohen and Levinthal (1990); Smith et al (2005)
cross-trained personnel/generalists	Ettlie and Reifeis (1987)			Cohen and Levinthal (1990)
Ability to commuinicate and Teach	Shani et al. (1992)			Leonard-Barton (1988)
trouble shooting ability (ability to handle unexpected crises and deviations from plans)			Pinto and Mantel (1990)	
network				Smith et al (2005)
Team characteristics				
functional diversity	Ettlie and Reifeis (1987); Beatty (1992); Hottenstein and Dean Jr. (1992); Ettlie and Reza (1992); Small and Yasin (1997); Co et al. (1998); Tyre and Hauptman (1992)		Ancona and Caldwell (1992); Pinto et al. (1993); Cummings (2004)	Cohen and Levinthal (1990)
Tenure diversity			Ancona and Caldwell (1992); Cummings (2004)	
Demographic diversity (age, gender, tenure, industry experience)			Cummings (2004)	
Teamwork quality			Hoegl and Gemuenden (2001)	
Physical proximity			Pinto et al (1993), Hoegl and Proserpio (2004)	
psychological safety /culture of risk taking		Edmondson (1999); Edmondson (2003); Baer and Freese (2003)		Smith et al. (2005)
Implementation policies and organization				
Goals and task requirements				
challenging but realistic (e.g., supplemented by tools and support)	Beatty (1992), Linderman et al (In-press)			
clear and well communicated	Beatty (1992)		Pinto and Mantel (1990)	
accepted throughout	Beatty (1992); Hewitt (1995)		Pinto et al (1993)	

Table 2.1 (continued)

Variables	Theoretical Bases			
	Innovation Implementation		Project Management	Absorptive Capacity and Knowledge Management
	Operations Management	Organization		
Support				
Communication and information infrastructures	Hewitt (1995); Meyers et al. (1999); Frohlich and Dixon (1999)			
Training and preparation (quality and quantity)	Co et al. (1998); Small and Yasin (1997); Meyers et al. (1999)	Klein and Sorra (1996); Klein et al. (2001)		Fedor et al. (2004)
Organizational adaptation	Leonard-Barton (1988); Frohlich and Dixon (1999); Tyre and Hauptman (1992)			
Resource Slack / availability	Meyers et al. (1999), Hottenstein and Dean Jr. (1992)	Klein et al. (2001)		Fedor et al. (2004)
Incentives for change		Klein and Sorra (1996); Klein et al. (2001)		
Top management support		Klein et al. (2001), Sharma and Yetton (2004)	Pinto and Mantel (1990)	
Coordination				
external to the plant	Tyre and Hauptman (1992); Stock and Tatikonda (2004)			
Organization Characteristics				
culture (Quinn and Roughbaugh , 1981l)	Zammuto and O' Connor (1992); McDermott and Stock (1999)			
innovation-value fit		Klein and Sorra (1996); Detert and Schroeder (2000); Holahan et al. (2004)		
implementation climate		Klein and Sorra (1996); Klein et al. (2001); Holahan et al. (2004)		
project manager-line manager relationship			Turner (2004)	
past experience with innovation				Zahra and George (2002); Smith et al. (2005)
cross-trained employees	Shani et al. (1992)			Cohen and Levinthal (1990)
communication skills	Shani et al. (1992)			
Innovation Characteristics				
incremental/radical improvement	Hottenstein and Dean Jr. (1992)			
proven/ new & untried	Tyre and Hauptman (1992); Hottenstein and Dean (1992), Stock and Tatikonda (2004)	Edmondson (2003)		
extent of equired change	Tyre and Hauptman (1992)	Edmondson (2003)		
source of knowledge (internal/external)	Sen and Rubenstein (1989)	Edmondson (2003)		Menon and Pfeffer (2003); Fedor et al. (2003)
Institutional distance from source				Jensen and Szulanski (2004)

Past empirical studies on MPI implementation also suggest that these characteristics have positive association with higher implementation performance. These include level of technical competence (Hewitt 1995), extent of cross-training and cross-functioning (Ettlie and Reifeis 1987; Shani et al. 1992) and communication and teaching skills (Leonard-Barton 1988; Shani et al. 1992). Pinto and Mantel (1990) also find ability to handle unexpected crises and deviations from plan as an important desirable characteristic of project team members.

Beside individual characteristics, the characteristics of the team are also important. These include diversity, teamwork quality, physical proximity of team members, and psychological safety. Diversity is the most frequently studied team characteristics. While diversity has been generally recommended, empirical findings have been mixed. Diversity is advocated in innovation teams as it brings in different perspectives and because members have access to a more diverse set of knowledge (Cohen and Levinthal 1990). Several types of diversity have been suggested. These include functional diversity, tenure diversity, and demographic diversity.

The absorptive capacity literature has a good explanation of the effect of diversity on absorptive capacity. An organization's absorptive capacity depends not only on the absorptive capacities of its individual members as mentioned above. It also depends on linkages and networks the individuals have with external environment to be able to absorb information and knowledge (Smith et al. 2005), as well as the ability to internally share knowledge and information and transfer them to where they can be utilized . Thus, while diversity of background is useful for receiving knowledge from outside, it also makes internal communication difficult. Cohen and Levinthal (1990) suggest that there is "a trade-off in the efficiency of internal communication against the ability of the subunit to assimilate and exploit information originating from other subunits of the environment".

Smith et al. (Smith et al. 2005) find that functional diversity of top management and knowledge workers, a measure of knowledge stocks, in addition to years of formal education, has a positive association with the ability of an organization to create new knowledge. Evidence in support of benefits of functional diversity on innovation implementation and project management comes both from case studies (Ettlie and Reifeis 1987; Beatty 1992; Hottenstein and Dean Jr. 1992) and from large-scale empirical tests (Ettlie and Reza 1992; Tyre and Hauptman 1992; Pinto et al. 1993; Small and Yasin 1997; Co et al. 1998).

Ettlie and Reza (1992), for example, find in correlation analyses that integration of functions in an organization has significant correlation with improved performance due to an implementation of a purchased process technology. Small and Yasin (1997) find a positive impact of team-based project management practice (a construct which includes use of multi-disciplinary teams) on operational improvement for some AMT types. Co et al. (1998) also find a positive relationship with the use of multi-functional team and AMT implementation performance. From the project management literature, Pinto et al. (1993) find cross-functional cooperation to have positive relationship with perceived project's operational task outcomes. On a related variable to functional diversity, Tyre and Hauptman (1992) found that functional overlap has a negative effect on startup speed but a positive effect on operational improvement.

However, Ancona and Caldwell (1992) find a direct negative effect of functional diversity on technical performance and overall performance of product innovation projects. The authors also find an indirect positive effect through greater degree of external communication, which has a significant positive effect on technical performance. However, the positive indirect effect is not large enough to overcome the direct negative effect. There is also no significant direct effect on budget or schedule achievement.

Cummings (2004) also find no direct effect of functional diversity on work group performance. He found only a positive moderating effect of functional diversity on the external knowledge sharing-performance relationship and no significant moderating effect on internal knowledge sharing-performance relationship. Ancona and Caldwell (1992) and Cummings's (2004) findings support Cohen and Levinthal's (1990) and Smith et al.'s (2005) contention that functional diversity only is valuable in enhancing the communication to external sources.

Tenure diversity and demographic diversity have been less well studied and supported. Ancona and Caldwell (1992) find that tenure diversity (measured as coefficient of variation of years employed by the organization) has a positive relationship with group internal process (behaviors aimed at organizing members to get work done, e.g., goals defining, work plan development and work prioritization) but no effect on external communication. However, the direct effect of tenure diversity is non-significant on innovation quality and team's satisfaction with the outcome of the project, and negative on budget and schedule achievement. Tenure diversity is also part of the measure of demographic diversity of teams in Cummings (2004), which finds no significant relationship of demographic diversity and project performance.

Hoegl and Gemuenden (2001) investigate the relationship between teamwork quality, the quality of interaction among team members, and performance of 145 software development projects. Their study specifies teamwork quality as a higher order construct encompassing communication, coordination, balance of member contributions, mutual support, effort and cohesion. Structural equation models show that teamwork quality is positively associated with project performance (effectiveness and efficiency) as rated by team members, team leaders and managers and personal success of team members measured by work satisfaction and learning.

Pinto et al. (1993) find that physical proximity among team members positively affects cross-functional cooperation. Hoegl and Proserpio (2004) also find that team member proximity, measured perceptually, is positively related to five of the six dimensions (except balance of member contribution) of teamwork quality.

Edmondson (1999) defines psychological safety as a shared belief that the team members are safe for personal risk taking. Psychological safety results in increase confidence that members have in taking initiatives due to reduced concerns about others' reactions that pose threats (embarrassment or punitive actions) to many learning behaviors. Edmondson (1999) find that psychological safety positively affects learning behavior which is associated with team performance and Baer and Freese (2003) find positive moderating effect of psychological safety on the effect of organizational process innovativeness (measured as change on 12 dimensions) on company goals and financial performance. Sarin and McDermott (Sarin and McDermott 2003) also find a positive relationship between participation-oriented style management (where team leader invites member's active involvement in the decision making process) and learning.

2.2.2 Implementation policies and support

Implementation policies and support include quality and quantity of training, provision of technical assistance to users, availability of rewards, communication regarding reasons for change, provision of time to experiment, and user-friendliness of the technology. Klein et al. (2001) find support for direct positive effect of the composite measure of the six implementation policies and practices on performance. Klein and Knight (2005) note that these policies and practices seem to be cumulative and compensatory. The following discusses finding on more specific implementation policies and activities.

Goals and task requirements

Through analyses of cases, both Beatty (1992) and Hewitt (1995) suggest that project goals need to be realistic, clear, well communicated, and accepted throughout the organization. One particularly effective way to communicate goals is by providing incentives and rewards for specific behaviors and/or overall project success (Klein and Sorra 1996; Klein et al. 2001). However, Pinto and Mantel (1990) find clear project mission not significantly related to project success, but detailed specification for individual action steps related to project success. Pinto et al. (1993) find that the existence of goals that drive the need for changes unify functions within organizations to collaborate.

In addition, challenging goals can help motivate organizational members, but only when the members are equipped with resources to carry out actions. Linderman et al. (2006) drawing on goal-setting literature find that challenging goals are positively associated with six-sigma team performance only when project team members adhere to six sigma tools and mechanisms.

Support (Top management and resource, communication and information infrastructure, Modification to MPI and existing organization)

Top management support is highly important to MPI implementation success because it is a precondition for resource support, but its benefit may be contingent on other variables. Top management support provides legitimacy to everyone in the organization as well as reinforces employees' collective belief that the use of the innovation will be rewarded. It leads to commitment from line managers to get the job done by providing resources such as time, equipment and technical skills (Kerzner 1987). Moreover, since many projects require collaborations between line managers and project managers, executive commitment to the project is valuable in resolving conflicts between line and project managers (Kerzner 1987; Belassi and Tukel 1996).

Pinto and Mantel (1990), however, find no significant relationship between top management commitment and project performance, and Klein et al. (2001) find that it is availability of financial resources, not top management support, that is significantly related to quality of policies and practices. Sharma and Yetton (2004) show in a meta-analysis that the effect of management support on information systems implementation success is contingent on task interdependence (the degree to which implementation tasks need to be performed together). Only at high level of interdependence between functions does top management support have significant effect on success.

Given that an MPI implementation often requires collaboration between functions and departments, the interface between these functions and departments need to be integrated. Collaborative work between different functions requires compatibility in modes of communication. These include, for example, compatible CAD system for design and tooling, and common reporting and command center (Hewitt 1995; Meyers et al. 1999).

Beatty (1992) notes that one of the biggest obstacles to implementing AMT is the integration of the new production process with design and adjacent manufacturing processes. There needs to be a plan of how the new process will connect with existing activities. In some cases, the cost of creating the software that bridges among manufacturing systems and design that are not compatible offset the saving in acquisition costs. Frohlich and Dixon (1999) study the effects of adaptations of human resources, information systems, equipment, materials and operational structure on improvement in operational performance after AMT implementation. The only adaptation that was significantly associated with improved performance is information system adaptation.

The lack of fit between a MPI and the organization necessitates modification to the MPI and the organization. Tyre and Hauptman (1992) find that projects where more modifications to the MPI occur take less time to implement and better achieve the technical goals of the project. On the other hand, one of the most significant modifications to the existing organization is training users of the process. Not only does training provide operators with proper skills, it has implications on positive motivation, attitudes and commitment/ownership (Hottenstein and Dean Jr. 1992; Meyers et al. 1999). Co et al. (1998) find that AMT projects in which education and training are stressed by top management and are provided to all level of team members are associated with higher success. Small and Yasin (1997) find that workers' preparation is positively associated with better operational performance. Meyers et al. (1999) also identify training of staff on the new technology as critical to industrial process implementation.

Lastly, some studies find the power relationship between the people involved in the project to be a significant factor of success. Kerzner (1987) find that a clear reporting structure between workforce to the project/line manager and manager to top executives as well as the parity of power between project managers and line managers improve project performance. Turner (2004) finds collaboration between project manager and project owner (e.g., functional areas) to lead to greater project performance.

2.2.3 Organizational characteristics

The third set of antecedents for MPI project success involves characteristics of the organization. Studies have investigated implementation climate, culture, the fit between an innovation and the organization, and resource availability. Not surprisingly, many of the policies and practices mentioned in previous sections are aimed at creating desirable organizational characteristics and/or eliminating undesirable ones.

Recent studies attempt to capture necessary organizational characteristics in one single construct, implementation climate. Implementation climate is defined as targeted users' shared summary perceptions of the extent to which their use of a specific innovation is rewarded, supported and expected within their organization (Klein and Sorra 1996). Klein and Sorra (1996) argue that,

> "A strong implementation climate fosters innovation use by (a) ensuring employee skill in innovation use, (b) providing incentives for innovation use and disincentives for innovation avoidance, and (c) removing obstacles to innovation use."

Klein and Sorra (1996) offer an example from their case study of an implementation failure where targeted users have achieved satisfactory level of skill to operate new technology after training and are excited with the prospect of improvement. The failure is attributed to limited on-the-job assistance and the lack of incentives to change.

This contention is supported by Klein et al. (2001). Holahan et al. (2004) also find support in a study on implementation of a computer technology in science education. In addition, they find that implementation climate mediate the positive effect of organizational receptivity toward change on implementation effectiveness. Baer and Freese (2003) find a positive effect of climate for initiative on implementation goal achievement, and that the effect is greater with the extent of change.

Another collective aspect of an organization is its culture. Quinn and Rohrbaugh's (1981) competing values model suggests that organizations can be distinguished along two axes reflecting different value orientations: flexibility-control dimension, and internal-external focus. Scholars have suggested that these value orientations have implications on the implementations of new practice and technology. Klein and Knight (2005) suggested that "inclination toward stability" could hinder implementations. In addition, a perspective from project management emphasizes that corporate culture should not view project management as a threat to established authority or a cause for unwanted change (Kerzner 1987). However, McDermott and Stock (1999) find no association between any cultural orientation and operational improvements ensuing AMT implementation.

Another important organizational characteristic is the fit between an innovation and the organization. Klein and Sorra (1996) suggest that commitment to the use of an innovation depends on the perceived fit of the innovation to employee's values, the generalized enduring beliefs about desirability of actions and their consequences. According to this, employees are more willing to adopt an innovation if the innovation fosters/builds on existing values. A company that values production performance more than learning is less likely to sacrifice production time to learning. Similar arguments are made in TQM implementation culture (Detert and Schroeder 2000). Holahan et al. (2004), however, do not find a significant effect on innovation-values fit on implementation effectiveness. The authors, however, note that this could be due to low variance in the value measure.

Organizational resource availability is also as an important precondition for success. The most important resource is personnel. Shani et al. (1992) found in a case study that the lack of cross-trained employees and the lack of communication skills (including language skills) necessary for group-based work were barriers to a successful implementation of AMT.

Other characteristics such as organizational size, geographical region, type of institution (university vs. clinic, suggesting past innovation experience), do not distinguish successful implementing efforts and unsuccessful ones (Edmondson et al. 2001).

2.2.4 Invention Characteristics

The literature suggests several characteristics of an innovation that affects implementation performance. These characteristics include: newness of technology, amount of change required, tacitness of knowledge embedded in the new technology and source of invention.

Several studies indicate that implementations of a newer technology are less successful than implementations of an older/mature technology (Hottenstein and Dean Jr. 1992; Tyre and Hauptman 1992; Edmondson et al. 2003; Stock and Tatikonda 2004). The main reason is that technical problems that have not yet been resolved result in unreliability of technology (Klein and Knight 2005).

Amount of change required by the technology is also shown to worsen implementation performance (Tyre and Hauptman 1992; Edmondson et al. 2003). This is especially true when "an innovation challenges existing patterns of interdependence among individuals or groups" and when existing routines are well defined and supported (Edmondson 2003). Required changes in existing hierarchy and how works are conducted tend to hinder the implementation process (Klein and Knight 2005).

Tacitness of knowledge embedded in the technology is generally recognized to create difficulty in the learning process (Nonaka 1991). Edmonson et al. (2003) found that when an innovation requires tacit knowledge, it takes longer for the team to learn to excel at the task and team stability is greatly required to smooth out the process.

Another important characteristic of innovation is the source of an invention (Argote et al. 2003). Previous studies view this variable as a dichotomy of internal versus external invention source. Some authors believe that external innovation is generally more difficult to implement (Sen and Rubenstein 1989; Edmondson et al. 2003; Fedor et al. 2003). Other authors (Menon and Pfeffer 2003; Menon et al. 2006) provide arguments for why a company may tend to perceive external innovation to be of greater value, and, thus, can be more motivated to adopt and implement the invention.

Chapter 3 Theory development

3.1 Model overview

This study focuses on the effect of IID on manufacturing process innovation (MPI) implementation performance and the moderating effects of three variables: functional diversity of the team, team members' technical competence, and psychological safety. All three variables pertain to characteristics of the implementation team. Figure 1 shows the research model for this study.

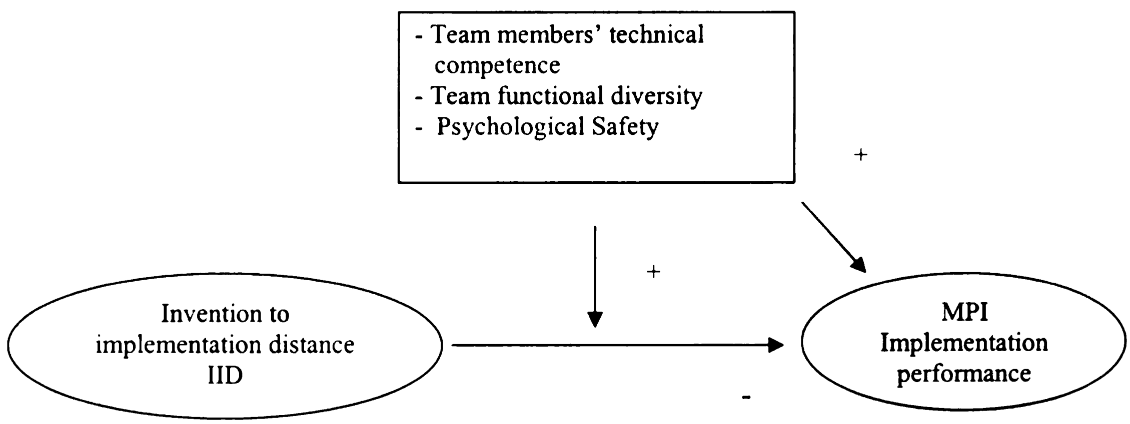

Figure 3.1 Theoretical Model

3.2 Hypotheses development

Direct effect of IID on implementation performance

There is currently no conclusive evidence for either positive or negative influence of IID. Studies that exist can only provide anecdotal evidence for its effect. Explicit large-scale empirical investigation on the relationship is lacking.

Studies of Menon and Pfeffer (2003) and Menon et al. (2006) provide evidence for a positive effect. Menon and coauthors argue that fear of internal rivalry will lead organization members to value internal knowledge lower than external knowledge. However, in support of a negative effect, Fedor et al.'s (2003) results also show that while internal knowledge generation has positive effect on product and process innovation project team's evaluation of success, external knowledge generation has no significant direct effect and a negative moderating effect on the relationship between organizational support and performance.

Two reasons suggest that, ceteris paribas, IID should result in lower MPI implementation success. First, externally acquired technology may be physically and culturally unsuitable to the receiving organization. A potential cause for these mismatches is that systems are often developed with little or no consideration of existing conditions at the innovation-adopting organization (Bostrom and Heunen 1977). Physically, this results in a mismatch between existing technological equipment (e.g., tools, machine and raw materials), organization and structure (e.g., assembly processes and shop floor layout), and human resource (e.g., skill level) and those required by the new technology (Sen and Rubenstein 1989). The more that invention is done "externally", the less likely the consideration of fit between the invention specs and the organizational characteristic will have been taken into account in the design process. As this logic readily applies to physical and organizational distance, it applies to temporal distance as well. Even an invention that is designed specifically for the implementing organization can become unfit to the organization if time passes before it is implemented.

Changes in the working environment such as in the level of workers' skills, a loss of key personnel, or deterioration of equipment over time can render an invention unfit for an organization.

This logic can be illustrated in adoptions of best practices and AMT. Adoption of a best practice is an implementation of a set of routines that may have been invented without any consideration of adopting firm's readiness of physical assets and equipment, culture, complimentary procedures, and staff of the firm. Similarly, many AMT systems (e.g., robotics and computer-aided design) are purchased off-the-shelf from a technology supplier that does not consider how the new machine will interface with the rest of the system, potentially causing extensive process integration requirements (Beatty 1992). These could include modifications of bill of material database structure to create consistency to facilitate data transfer.

Similarly to physical mismatches, cultural mismatches also reduce an organization's success in managing the implementation process. Klein and Sorra (1996) and Detert and Schroeder (2000) posit that commitment to the use of an innovation depends on the perceived fit of the innovation to employee's values, the generalized enduring beliefs about desirability of actions and their consequences. According to this, employees are more willing to adopt a MPI if the MPI fosters/builds on existing values. Since cultural beliefs and values are embedded in MPIs, an MPI that is invented closer to the implementation site in terms of physical, temporal and organizational distance is more likely to capitalize on existing values. This should be an opposing force to the positive effect due to less fear of internal competition (Menon and Pfeffer 2003). Jensen and Szulanski (2004) find some support that the source-recipient difference in culture/value system reduces legitimacy of a practice in the eye of the recipient, thus reducing recipient's motivation in implementing the practice.

For example, a plant manager whose performance is assessed by plant utilization may oppose practices such as preventive maintenance and kaizen as these activities appear to detract away production time and their benefits do not arise until later. Another example is that an organization that highly values its people will be more resistant to process innovations that require laying off workers. As IID increases, the degree of fit between an invention and employees' values are likely to decline.

The lack of physical and cultural fit as a result of greater IID may increase amount of change required. This often prompts resistance as they challenge existing structure of political influence, are more intimidating to organizational members, and involve greater uncertainty of requirements (Damanpour 1996). Edmondson (2003) note that technology implementation is "especially difficult when an innovation challenges existing patterns of interdependence among individuals or groups". Tyre and Hauptman (1992) also find negative effect of amount of required change on speed of implementation (measured in absolute term).

The second primary reason for IID's negative effects on implementation performance is that IID limits direct communications between an implementing unit and the innovation source. In the context of innovation implementations, these include: communication to seek clarifications or advice and explanations on the logic behind a practice, soliciting assistance in training, or merely additional direct observations.

Studies in project team setting indicates that physical proximity among team members influence type and frequency of interaction, exchanges and communication (Pinto et al. 1993). Hoegl and Proserpio (2004) find team members' proximity to each other leads to better communication, coordination, mutual support, effort and cohesion among team members. Hoegl and Gemuenden (2001) showed that these teamwork quality variables are positively associated with team performance.

While these findings pertain to physical distance among team members, the logic also applies in the relationship between an invention source and recipient. Temporal and organizational distances also likely have similar effects in limiting the amount and effectiveness of communication, interaction and observation conducted between innovation implementing unit and the innovation source. An example of communication limitations due to temporal distance is leaving or retiring of key designers of the process within the organization over time.

The following hypothesis is advanced based on the above arguments:

> H1: IID is negatively associated with MPI implementation performance.

Direct and moderating effects of other variables

This study focuses on three important variables from a learning perspective: 1.) implementation team members' technical competence (Ettlie and Reifeis 1987; Hewitt 1995; Cohen et al. 1996; Smith et al. 2005), 2.) functional diversity of team members (Ettlie and Reifeis 1987; Sen and Rubenstein 1989; Small and Yasin 1997; Co et al. 1998) and 3.) team psychological safety (Edmondson 1999; Edmondson et al. 2001; Baer and Frese 2003; Edmondson 2003). The essential argument of this portion of the study is that these three variables as manifestations of learning potential, positively moderate the effect of IID on implementation performance.

Since the arguments on the interaction effects focus on learning, it is appropriate to note how greater IID may require greater amount of learning. First, building an earlier argument, greater IID often requires systemic organizational and cultural shifts as well as adjustment of the invention. More required adaptation to the invention or to the organization requires greater amount of learning and problem solving for the implementation team.

Second, the IID increases the difficulty and the costs of , and in some cases prevent, direct communications with the source of the invention. These include further observation, discussion of the logics behind the practice with personnel from the inventing unit, and seeking assistance (e.g., training) directly from the source. When it is required, the implementing unit will need to be more involved in independent (of the source) information seeking, acquiring insights into the practice and figuring out requirements. Thus, in order to implement externally invented technology successfully, a greater amount of learning will be required in general.

The following is the discussion of the direct and moderating effects of the three variables that contribute to an organization's potential to learn.

Implementation team members' technical competence

Team members' technical competence is defined as the level of technical expertise represented by the project team. This team aspect is emphasized because the innovation implementing process often requires extensive learning and problem solving. Since solution to a problem is a form of knowledge, problem solving is a knowledge creation activity. The ability of a team to learn and create knowledge (i.e., problem solving in this case) depends largely on its individual members' absorptive capacity, because individual members are agents that acquire, assimilate, transform and exploit knowledge.

Past findings on the effect of technical competence on performance have been mixed. Smith et al. (2005) find a positive association between years of formal education and an organization's ability to create knowledge. Pinto and Mantel (1990) find that team member's problem solving ability is significantly associated with budget, schedule and technical performance, however, technical expertise does not have a significant effect on project's success. Subramaniam and Youndt (2005) also find that the presence of technical competent individuals in the organization has a positive effect on the organization's ability to innovate when there is strong social interaction among the individual organizational members.

Prior knowledge of a person, reflected by the depth and breadth of his knowledge, is said to limit the individual's ability to understand and create new knowledge. This is because learning is a process of establishing linkages between new information and existing memory and knowledge generation is a process of drawing on existing knowledge and applying it in a different context (Cohen and Levinthal 1990). Thus, the more prior technical knowledge a team member possesses, the more linkages he can make, and the easier it will be for him to learn. Thus, it can be argued that team members' technical competence, their prior technical knowledge, is important to innovation implementation success (Leonard-Barton 1988; Cohen and Levinthal 1990; Smith et al. 2005).

Implementations of innovation often require specific skills. For example, AMT implementations often need process integration that requires programming skills. New procedure implementations require analytical ability of the team in order to understand logics behind a new process and knowledge of the environmental context at the adopting organization to properly apply new processes.

H2 a: Implementation team members' technical competence is positively associated with MPI implementation performance.

As argued above, team members' technical competence contributes to team's absorptive capacity. Through the ability to learn the team will better resolve fit issues resulting from greater IID. Thus, IID should less negatively affect implementation performance when the team is composed of technically competent members.

H2 b: Implementation team members' technical competence positively moderates the effect of IID on MPI implementation performance

Functional diversity of implementation team

Many functions will be affected by organizational adaptations required in adopting new manufacturing innovations (Ettlie and Reifeis 1987; Hottenstein and Dean Jr. 1992). These functions typically include design engineering, production control, maintenance, production/manufacturing, quality control, purchasing, and management information system. Functional diversity is defined as the extent to which multiple functions are represented on the implementation team

Including representative members of these functions in implementation team has several benefits. These include: breadth of knowledge of the implementation team (more access to more variety of knowledge, thus greater absorptive capacity), wider range of perspectives, greater opportunity of detecting potential problems associated with each function and addressing them beforehand, and increasing employees' buy-in and support as their concerns are heard (Ettlie and Reifeis 1987; Sen and Rubenstein 1989; Davenport 1993; Small and Yasin 1997).

The use of a cross-functional implementation team has been found in some studies to be a success factor in innovation implementation and project management (Ettlie and Reifeis 1987; Sen and Rubenstein 1989; Tyre and Hauptman 1992; Davenport 1993; Pinto et al. 1993; Small and Yasin 1997). For example, involvement of R&D personnel assist in providing solutions to modification of equipment and providing training to the implementing unit's employees as R&D personnel tend to be the most current and knowledgeable about new technologies (Sen and Rubenstein 1989; Sen and Rubenstein 1990). Inclusion of manufacturing personnel on the team provides information on workforce skill level and current practices, informing the team what needs to be changed.

Based on the above arguments, the following hypothesis is advanced:

> H3 a: Functional diversity of the implementation team is positively associated with MPI implementation performance.

As argued above, functionally diverse teams exhibit greater team's absorptive capacity due to its breadth of knowledge embodied in the personnel. Breath of knowledge affords the team access to more sources of knowledge and a greater variety of perspectives that results in better solutions to problems (Cohen and Levinthal 1990; Zahra and George 2002). Since functionally diverse implementation teams are better at learning and solving problems (a form of knowledge creation), they are better able to address learning and problem solving requirement resulting from mismatches due to IID and lack of direct communication. This argument leads to the following hypothesis.

> H3 b: Functional diversity of the implementation team positively moderates the effect of IID on MPI implementation performance.

Team's psychological safety

Psychological safety is a shared belief that team members are safe for personal risk taking (Edmondson 1999). Psychological safety is reflected in "a sense of confidence that the team will not embarrass, reject, or punish someone for speaking up" (Edmondson 1999). It has been found that psychological safety is positively associated with learning behaviors (Edmondson 1999), which are important to successfully implementing a new MPI.

Learning can also be thought of as a process of detecting and correcting errors provides another perspective on (Argyris and Schon 1978; Edmondson 1999). Thus, the ability of a group to learn depends on team members' ability to detect and correct errors in their understanding and beliefs. Behaviors that have been shown to be effective in learning include feedback seeking from colleagues, experimentation with new ways of doing things, voicing opposing opinions and discussion of errors (Edmondson 1999). Since these behaviors are potential sources of embarrassment and threat to career advancement, team members in low psychological safety environment tend to conform to the norms and suppress unusual information or observations.

Edmondson (2003) studies implementations of new cardiac surgery technology which requires radical changes in operational procedures. She finds that in surgical teams where the implementation of this new technology is framed as a learning opportunity, members freely voice their opinions and suggestions without fear of any social/career punishment. This so called psychological safety encourages learning behaviors which result in more successful implementation of the technology (apply it to more variety of cases, reducing operation time and continued usage). This line of argument has also been supported by findings of Baer and Freese (2003) on organizational benefits from adopting new manufacturing innovations and Sarin and McDermott (2003).

H4 a: Psychological safety is positively associated with MPI implementation performance

As argued above, psychological safety results in exercising of effective learning behaviors. Thus, implementation teams with high psychological safety are better able to resolve the mismatches issues due to IID. This argument leads to the following hypothesis.

H4 b: Psychological safety positively moderates the effect of IID on MPI implementation performance

Chapter 4 Methodology

This chapter covers methodological issues in this study. These include data collection and sample, measured variables and scale reliability and validity.

4.1 Data Collection and Sample

4.1.1 Survey method

The intent of this study is to test a set of generalizable hypotheses in manufacturing process innovation (MPI) implementation projects. Thus, the data to be used should represent companies from different sizes, geographical locations and industries. Three reasons make a survey an appropriate mode of data collection for this study.

First, it allows gathering of a large amount of data economically in a relatively short period of time. Second, a survey can cover a geographically dispersed group of population. The population of this study is MPI implementation projects in manufacturing plants in North America. The vast region makes traveling to sites cost prohibitive. Lastly, survey provides privacy in responding and anonymity to respondents. It requires no face-to-face encounter making respondents more comfortable of sharing information without disclosing their full identities, as well as insulating respondents from expectation of an interviewer which may affect findings of the study (Mangione 1998).

4.1.2 Survey administration

This study collected data online between October 2006 and January 2007. Key advantages of online data collection are reduced response time, lower administration cost (printing and postage savings should offset programming costs) and reduced data entry error (Granello and Wheaton 2004). Four invitations in total were sent to each people on the contact list. An invitation letter (regular mail), an e-mail invitation, a postcard reminder and a final e-mail invitation were sent. Follow up phone calls were also made to a list of random non-respondents to assess non-response bias.

Generally cited limitations of online survey include lower representativeness of the sample and lower response rate (Granello and Wheaton 2004). Web-based survey may exclude people who are not comfortable using or do not have a ready access to the internet. However, given the target respondents were production and engineering managers, nearly all should have had access to the internet. Misrepresentation of the population, therefore, should be limited. In fact, from the follow-up phone conversation with 102 non-respondents, none of the eligible people to participate in this study mentioned not having access to the internet as a reason for not participating.

While responses have been shown to be lower in online surveys, to enhance the total number of responses, surveys were sent to as many people as possible; This was possible due to lower administration cost (Granello and Wheaton 2004). Several strategies to increase response rate were also used. These include multiple reminders (in more condensed intervals than done in paper-based surveys), use of closed-ended questions when possible to lower abandonment or dropout rate, and respondent-friendly designs.

A few principles of respondent-friendly designs suggested by Granello and Wheaton (2004) were followed. These included: a motivational welcome screen; formats that are similar to paper-and-pencil formats; limited line length to reduce the need for left-to-right scrolling; and computer operation instructions for different question formats at the location in the survey where the instructions will be implemented, rather than at the beginning of the instrument.

4.1.3 Population, unit of analysis and sample selection

The population in this study is completed MPI implementation projects conducted in the United States. Since the focus of this study is the effects of characteristics of the invention source and the implementation teams on implementation performance, required information is at the project level from the participants. Target respondents were mid- to high-level managers and engineers from companies in Standard Industry Codes (SIC) 20-39 (manufacturing) who had recently been involved in a completed MPI implementation project. Personnel at these levels have direct involvement with MPI implementation projects (of various sizes) while at the same time are knowledgeable and experienced enough to assess and provide answers pertaining variables in this study. Contacted respondents were also requested to provide additional project members that can be contacted for a second opinion. For projects that have multiple usable responses, averages of the responses were used.

This study used a mailing list obtained from Society of Manufacturing Engineers (SME), a leading national organization of manufacturing and production engineers. SME list contains 700,000 individuals who are associated with SME as subscribers of SME magazines and as members. To ensure representation of the sample in terms of plant size and industry, a stratified sample is drawn from SME's member list.

Table 4.1 Distribution of observations across industries by SIC code

SIC	Industry description	%
20	Food and kindred products	1.78
21	Tobacco products	0.00
22	Textile mill products	0.59
23	Apparel and other finished products made from fabrics	0.59
24	Lumber and wood products, except furniture	1.78
25	Furniture and fixtures	6.51
26	Paper and allied products	0.59
27	Printing, publishing, and allied industries	1.78
28	Chemicals and allied products	1.78
29	Petroleum refining and related industries	0.59
30	Rubber and miscellaneous plastics products	3.55
31	Leather and leather products	0.59
32	Stone, clay, glass and concrete products	5.33
33	Primary metal industries	2.37
34	Fabricated metal products	26.63
35	Industrial and commercial machinery and computer equipment	15.38
36	Electronic and other electrical equipment and components	8.28
37	Transportation equipment	5.33
38	Measuring, analyzing and controlling instruments	5.92
39	Miscellaneous manufacturing industries	10.65
Total		100.00

A set of keywords in the job title including management, senior, director, leader, engineering, project, process, systems, production, operations, plant, and quality was used to identify managers that were likely to have been involved in implementing a new MPI. The identified list included managers from plants with employment of at least 100 only. A total of 3,492 contacts were randomly selected to closely match the distribution of companies across manufacturing industries in the U.S., by SIC codes according to Almanac of Business and Industrial Financial ratios (Troy 2006). Tables 4.1 and 4.2 summarize the distribution of the 169 observations in the final sample for the analyses.

Table 4.2 Distribution of observations

Respondent's position	%
First-level Management	7.48
Middle Management	51.40
Upper Management	34.58
Others (e.g., researcher, engineer, consultant)	6.54
Company's employment globally	%
Between 501-1000 people	41.46
Between 1001-5000 people	10.57
More Than 5000 people	47.97
Scope of impact	%
A single work center	11.90
A production line	37.50
A department	27.98
The entire plant	14.88
Multiple plants	7.74
Plant's employment	%
100-249	37.72
250-499	21.56
500-999	17.37
1000-2499	15.57
More than 2500	7.78
Type of technology	%
Decision Support	2.96
Communication	4.14
Equipment replacement	75.15
Procedure change	11.83
Process Automation	5.92
Primary reasons for implementation[2]	%
A new product launch	20.71
A product modification	9.47
Kaizen/Continuous improvement	15.98
Parent corporation requirement	1.18
Customer's demand	46.15
Vendor's suggestion	7.10
Others (e.g., cost saving, outdated/broken equipment, process improvement, safety issue, capacity expansion)	27.22

[2] Some respondents cited more than one reason.

4.1.4 Selection and non-response bias

Two types of biases tend to persist in survey research: selection bias and non-response bias. Selection bias occurs when the sample that is obtained systematically excludes part of the population. Since target respondents of this study may have been active in multiple process improvement projects, they were asked to respond with regards to the most recent (within 9 months) completed MPI implementation projects in which they were directly involved. This approach was adopted to reduce tendencies to select certain types of improvement over the other (e.g., toward successful, or large-scale projects).

Non-response bias occurs when respondents are systematically different from non-respondents. To reduce this bias this study used two types of incentives to appeal to people of different natures. Participants were promised an executive summary of findings of this study, and offered a donation of $5 to their choice of Habitat for Humanity, National Childhood Cancer Foundation, Red Cross and UNICEF upon completion of the survey.

3,492 letters and e-mails were sent to managers asking for participation. 622 letters and/or postcards were undeliverable and returned, reducing the total pool to 2,870. 202 managers responded or referred someone else that responded on their behalf. However, of these 202 managers who responded, 41 did not complete the survey due to various reasons. 15 had never been involved in implementing a MPI, 22 had not been involved in a project that was completed within the last 9 months, two had insufficient time, and two did not provide a reason. This resulted in a total of 161 partial and complete surveys. An additional

10 people participated in the survey after follow-up phone calls. These people either had never received the invitations or had not had time to do it. Later, two responses were dropped due to excessive missing values, yielding a total sample size of 169.

The test of difference between respondents and non-respondents indicates that non-response bias should not be significant in this study. The majority of respondents (37 out of 39) who did not participate in the survey were actually not part of the target population for this study. To further assess the presence of non-response bias, phone calls were made to non-respondents. Information on 359 randomly selected non-respondents became available. 257 were either no longer employed by the company, or had relocated. 36 reported that they had never been involved or had not recently been involved in implementing MPIs. Only 66 of the non-respondents (18.38%) were actually eligible to complete the survey.

Chi-squared tests for difference in the distribution of industry and plant size between phone contacts and the whole contact list were conducted to check whether the results from the phone contacts were legitimate to use to check non-respondent bias. The chi-squared test results support that the 359 phone contacts are representative of the original contact list. (Chi-squared = 4.64, p = 0.33 for 5 plant size categories; and Chi-squared =17.23, p = 0.574 for 19 industry groups). Table 4.3 and Table 4.4 report the distribution of called individuals and the chi-squared statistic for the test of difference between the distribution of the called individuals and the rest of the contact list.

Table 4.3 Chi-squared test of equal distribution between called individuals and the contact list with respect to plant's employment

Plant's employment	100-249	249-499	500-999	1000-2499	> 2500	Total
Called people (O_i)	162	92	58	34	13	359
Expected (E_i)	150.51	100.24	51.61	37.52	19.12	359
(O_i-E_i)^2/E_i	0.88	0.68	0.79	0.33	1.96	4.64 (p = 0.33)

With the numbers from the phone contacts, the estimate number of qualified managers from the 2,309 (2,870-202-359) managers whom we had never heard from is 424 (66/359*2309). With 165 who reported online and 66 who reported on the phone that they were qualified to participate, the total estimate of qualified managers in the contact list came to 655, and the effective response rate among qualified managers was 25.80% (169/655). The effective response rate is comparable or better than recent similar studies (e.g. Sila (2007)). A recent survey by Tu et al. (2006) using SME mailing list reported a 10.7% response rate, further ensuring that the response rate for this study is typical or even better than typical.

Table 4.4 Chi-squared test of equal distribution between called individuals and the contact list with respect to SIC code.

SIC codes	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	Total
Called people (O_i)	5	4	2	7	21	5	7	17	1	24	3	5	5	96	56	30	12	15	44	359
Expected (E_i)	3.80	2.16	2.98	3.60	20.56	3.70	4.22	19.33	2.16	23.34	2.06	11.41	8.22	94.07	50.89	26.11	15.42	20.15	44.82	359
(O_i-E_i)^2/E_i	0.38	1.57	0.32	3.22	0.01	0.46	1.84	0.28	0.62	0.02	0.43	3.60	1.26	0.04	0.51	0.58	0.76	1.32	0.02	17.23 (p = .57)

Table 4.5 Chi-squared test of equal distribution between participants and non-participants with respect to SIC code.

SIC codes	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	Total
Participants (O_i)	4	1	1	3	11	1	3	3	1	6	1	10	4	44	26	14	8	10	18	169
Non-participants (E_i)	1.68	1.02	1.42	1.63	9.61	1.78	1.93	9.41	1.02	11.24	0.97	5.14	3.87	44.30	23.85	12.21	7.22	9.46	21.26	169
(O_i-E_i)^2/E_i	3.21	0.00	0.13	1.16	0.20	0.34	0.59	4.37	0.00	2.44	0.00	4.60	0.00	0.00	0.19	0.26	0.08	0.03	0.50	14.91 (p = .73)

Next non-response bias was further tested by comparing respondents and non-respondents. Chi-squared tests for distributions of survey participants' companies across plant size and industry were conducted. Chi-squared test rejected the null hypothesis of no difference between the distributions of respondents (N=169) and non-respondents (N=3331) across plant size at alpha = 0.05 (Chi-squared statistic = 12.72, p=0.013). Table 4.6 and Table 4.5 report the distribution of the sample across the 5 plant size categories and 19 SIC codes and the chi-squared statistic for the test of difference between the distribution of the sample and the distribution of non-participants.

The sample overrepresents larger plants (employment 500 and above) and underrepresents plants in smaller-size categories based on distribution of all companies in the U.S. However, this is not a serious threat to the validity of hypothesis tests. All plant size categories are fairly well represented, and it was expected that larger plants had a greater probability of having MPI implementation projects due to more resources to invest. The sample for this study should be representative of the population of interest for this study.

Table 4.6 Chi-squared test of equal distribution between participants and non-participants with respect to plant size.

Plant's employment	100-249	249-499	500-999	1000-2499	> 2500	Total
Participants (O_i)	62	37	30	27	13	169
Non-participants (E_i)	71.30	47.70	24.00	17.19	8.80	169
$(O_i-E_i)^2/E_i$	1.21	2.40	1.50	5.60	2.01	12.72 (p=0.013)

The chi-squared test, however, cannot reject the null hypothesis of no difference between the distribution of respondents and non-respondents across

19 SIC codes (chi-squared statistics = 14.91 p=0.728, Table 4.5). Test of difference in the mean plant size and performance (budget, schedule, technical and overall) between respondents in the first two waves and the latter two waves also show no significant difference between the two groups (p = 0.29, 0.27, 0.71, 0.27, 0.26). These tests give evidence that the projects that are reported are representative of projects that are carried out in manufacturing companies in the U.S.

4.2 Measurement instrument

4.2.1 Construction

This section discusses the construction of measurement instruments to ensure validity for variables in this study. It discusses procedures taken to ensure the validity of construct measures in the survey development stage, reasons for the use of perceptual measures, and measures used to prevent common method bias.

Validity refers to correspondence between a variable/construct and the operational procedure to measure it. One disadvantage of collecting information via mailed surveys is that respondents do not have the opportunity to clarify the meaning of each question. It is thus very important that questions are written so that variation in interpretation is limited. This requires clearly written and easy to understand language free of unclear jargon/technical terms. To ensure this, as much as possible, measures developed and tested in previous studies were modified and used. In addition, definitions of key terms were provided in the online survey to help clarify the scopes and meanings of terms used in the questions.

To enhance validity of the questions, five managers with experiences in implementing MPI read the survey questions and commented on readability and appropriateness of questions. Adjustments were made to these questions according to the comments from these managers.

Next, four rounds of Q-sorting for questionnaire items with Likert-type scales were conducted following procedures recommended by Stratman and Roth (2002). Q-sorting is an iterative process that helps assess and improve validity and reliability of constructs (Nahm et al. 2002). In each round participants were provided with definitions of each construct and a set of questionnaire items in random order. Participants were requested to assign each questionnaire item to a construct he/she believed the item was intended to measure. At the end of the round participants input were used to help refine questionnaire items to improve readability and discriminant validity. Revised questionnaire items and construct definitions were then given to a new set of participants.

Participants in the first two rounds consisted of nine doctoral students at Michigan State University. The first round had five participants and the second round had four participants. Participants in the third round were five manager-level personnel in manufacturing companies. Participants in the fourth round were 37 MBA students at Michigan State University. The average item placement ratio (percentage correctly sorted) for the 41 questionnaire items in the final round is 75.87% with a standard deviation of 20.79%. Item placement ratio of 70% or greater is generally considered acceptable (Moore and Benbasat 1991). A few items do not pass this criterion possibly due to the high interrelation among the constructs and the large total number of items that had to be sorted. Some adjustments were made to these items after the final round as appropriate. The placement rate for the final round of Q-sort is included as an Appendix 1.

This study used perceptual questions to measure most constructs. While objective questions are not affected by subjective interpretation (Starbuck and Mezias 1996), they are not always available or suitable. For example, a latent variable such as psychological safety is not objectively measurable. In addition, when objective measures are available, in different industries and project size and type the same value of a variable may imply significant difference. For example, timeliness may be measured by lateness as a percentage of original schedule, but for a project that was expected to last a day versus a project that is expected to last a year, 100% late means one day late versus one year late. Lastly, participants may be reluctant to share some objective information, especially cost figures. This can result in lower response rate and higher missing value rate. For these reasons, perceptual measures were used to capture the majority of the variables of interest in this study. Procedures recommended by Starbuck and Mezias (1996) were followed to improve accuracy of perceptual measures to reduce perceptual bias.

Lastly, common method bias refers to bias in findings that is attributable to the measurement method rather than to the construct of interest (Bagozzi and

Yi 1991). When one method is used to capture all constructs, it can result in observed dependent relationships between measures of different constructs that in fact do not exist (Podsakoff et al. 2003). However, Malhotra et al.'s (2006) findings confirm Cote and Buckley's (1987) findings that common method biases are usually not serious in single-method studies and that the biases are lower in studies for variables in marketing and information system than in psychology, sociology and education where variables are more abstract. Common method bias should be low in this study since the variables in this study are relatively more concrete, dealing with actual goals achievement, system and technology and characteristics of people on the team.

In order to reduce common method bias recommendations from Podsakoff et al. (2003) were followed in constructing the measures and the survey. First, the measures for independent and dependent variables were psychologically separated by having different response formats for the main independent variables (distance variables) and dependent variables (fill in the blank vs. Likert-type scales). Second, question order was counter-balanced in the questionnaire with dependent variables positioned before independent variables to reduce participant-inferred cause-effect relationship that were not actually present in the project. Lastly, the questionnaire was carefully constructed to reduce any ambiguity in interpretation, and anonymity was ensured to participants to reduce evaluation apprehension.

Harman's single-factor test was conducted confirmatory factor analysis (CFA). The CFA procedure compared chi-square difference from two CFA models, one with one method factor, and the other with hypothesized constructs. The chi-square difference of 455.627 with 36 degrees of freedom is highly significant (p= 4.20E-74). Therefore, the CFA indicates that common method bias does not significantly bias the results of this study (Podsakoff et al. 2003).

4.2.2 Measurement items

This section discusses the specific items that were used in the final survey. Items that empirical analyses of construct validity suggested low validity were dropped. The full survey is included as Appendix 2.

Performance variables

This study focuses on three types of MPI implementation project performance: implementation cost, timeliness and technical improvement. In this study, these three performances are measured as goals achievement to allow comparability across observations. These measures were modified from earlier studies on product innovation projects performance (Primo and Amundson 2002; Swink 2002). Since relative importance of each performance criteria is different in each project, this study also sought to measure overall performance.

Cost performance

Cost performance is defined as the degree to which expenses for the implementation project adhered to the initial planned budget of the project. The survey asked respondents to report their perception on different facets of cost performance compared to original budget with a 5-point Likert-type scale.

- How much man power was actually used in the planning, testing and installation of the new practice/technology? (significantly more than originally planned to significantly less than originally planned)
- How much capital expenditure was actually used in the implementation? (significantly more than originally planned to significantly less than originally planned)
- To what extent was the original budget/projected cost of the implementation project met? (significantly more than originally planned to significantly less than originally planned)

Timeliness

Timeliness is defined as how fast the implementation project is executed. Three anchors are used to judge timeliness: group's expectation, other similar projects undertaken in the company, and top management's expectation. Respondents were asked to state on a 5-point Likert-type scale format the degree to which they perceive how long the implementation took compared to the three anchors.

- How much time did the implementation actually take? (significantly more than originally planned to significantly less than originally planned)
- Relative to other similar implementation projects undertaken in this company, how long did this project take? (significantly more time to significantly less time)

- How satisfied were top management with how fast the implementation project took place? (very dissatisfied to very satisfied)

Technical performance

Technical performance is defined as the degree to which the performance of the new practice/technology matches the original operational improvement targets of the project (e.g., improving production quality, time or cost). Five items were used to measure overall technical achievement. Respondents were asked to indicate on a 5-point Likert scale the degree to which they agree/disagree with the following statements regarding the different facets of technical achievement of the project.

- Using the new practice/technology, we achieved greater productivities than we originally planned. (strongly disagree to strongly agree)
- The new practice/technology improved the quality of our process more than we had originally expected it would. (strongly disagree to strongly agree)
- The new practice/technology improved our responsiveness more than we had hoped. (strongly disagree to strongly agree)
- The new practice/technology achieved significantly better overall technical improvements than we had originally expected it would. (strongly disagree to strongly agree)

- The new practice/technology performed significantly better than we had originally expected it would. (strongly disagree to strongly agree)

Excluded item:

- The new practice/technology was not as effective or efficient as we had originally hoped it would be. (strongly disagree to strongly agree)

Overall performance

In addition to individual category performances, this study also measured overall performance. Each dimension of performance may be affected by conscious managerial decisions and intentional compromise. Thus, while an individual measure gives a more precise indicator of an outcome, it may not be as meaningful a measure of success or excellence as overall performance is. The survey asked participants for the weight assigned for each category of performance based on perceived importance of the success for the project.

- In evaluating the performance of this implementation project, what percentage weight (or importance) was given to each criterion of success? (Answers must add up to 100%) (Technical goals achievement; Budget attainment; Schedule adherence)

Distance from invention source

This study makes the distinction between the two processes in MPI: invention and implementation (see Chapter 3). This study measures three different types of distance between the implementation team and the invention source. The definition of the distance construct recognizes that there may be more than one source for an innovation. To capture this, we used the simple average and weighted average of the distance from each source. For weighted average, the weight is the proportion of the innovation attributed to the source. Degree of separation of a source of technology and the adopting unit was measured along three dimensions: physical separation, organizational separation and temporal separation.

Physical distance was measured by the distance between the inventing unit and the implementing unit.

- How many miles away was each design/invention source from the implementation site?

Organizational distance was measured as the strength of the relationship between implementation team members and the invention source. When the source was within the same plant, organizational separation was set to zero. Strength of relationship was measured with a 5-point Likert-type scale. The following question was used to measure organizational distance from contributing corporate support functions and the three most significant external sources.

- Please indicate the item that best describes the working relationship that personnel at the implementation site had with the source. (not close at all to extremely close)

Temporal distance was measured by asking respondents to estimate how long prior to the implementation process began had each source made the contribution to the design of the MPI.

- Approximately how many years before implementation did each source make their contribution to the design/invention?

Source contribution

Participants were asked to provide the contribution on the design of the invention each of the most important 3 sources of the invention had.

- What percentage of the design/invention of the new manufacturing practice/technology you described was done by: (Answers must add up to 100%)
  - Personnel (managers, engineers and workers) at the implementation site? (%)
  - Corporate support functions (engineers and others not located at the site)? (%)
  - External sources (vendors, suppliers, university labs, etc.)? (%)
- What percentage of the total design/invention did External source [1, 2 and 3] contribute? (%)

The following is the formula for calculating the weighted average of each of the three distances for each observation.

$$\text{Distance}_{ik} = \sum_j W_{ijk} D_{ijk}$$

where Distance is the calculated distance, W is the weight for each source by contribution, and D is the measured distance. The index i represents the observation, j represents the distance type (physical, temporal and organizational) and k represents the distance source (internal, corporate support functions, or external sources)

Team members' technical competence

Team member's technical competence is defined as the combined quality and depth of knowledge that was represented by people on the implementation team. Three 5-point Likert scale questions modified from Subramaniam and Youndt's (2005) measures for human capital were used.

- Implementation team members were highly skilled. (strongly disagree to strongly agree)
- Implementation team members were considered among the best people in the organization. (strongly disagree to strongly agree)
- Implementation team members were experts in their particular jobs and functions. (strongly disagree to strongly agree)

Functional diversity

This study used the entropy-based index developed by Pfeffer and O'Reilly (1987) to measure heterogeneity in a system, and adopted by Ancona and Caldwell (1992) to measure diversity. This index takes into account the proportion of team members from each function, as well as the number of functions present. Functional diversity is measured as, $H = -\Sigma(p_i(\ln p_i))$, when i denotes a represented functional home on the project team, and p_i denotes the fraction of function i on the team.

The following question asked the participant to identify the proportion of the MPI implementation team from 8 functions that have been identified in previous studies as functions that are typically involved with MPI implementation.

- What percentage of the personnel on the implementation team was from the following functional area? (Answers must add up to 100%) (Manufacturing engineering; Product design engineering; Quality control; Production control; Maintenance; Production/Manufacturing; Purchasing; Management information system; Others)

Psychological safety

Measures of psychological safety are drawn from Edmondson (1999). These measures tap the perception of the respondent on how the team members contribute through their reaction to opposing viewpoints and new ideas and their eagerness to help. The measures were 5-point Likert scale questions.

- If an implementation team member made a mistake on this team, it was held against him/her (R). (strongly disagree to strongly agree)
- Team members feared that bringing up problem/issues would have negative effects on their career prospects (R). (strongly disagree to strongly agree)
- No one on this team would deliberately act in a way that undermined my efforts. (strongly disagree to strongly agree)
- Each member of the implementation team felt they were valuable to the team. (strongly disagree to strongly agree)

Excluded items:

- People on this team sometimes rejected other members.
- It was safe to take a risk on this team.

Control variables

Several variables potentially interact, are correlated with the variables in the model, or are expected to explain significant amount of variances in the performance variables. These variables need to be controlled for to reduce biases in the results and enhance the precision of the findings. Variables that are likely to be correlated with the focal variables include provenness of technology, aggressiveness of goals, communication effectiveness within the implementation team and team size. Other variables that were expected to have significant explanation power include project selection rigor and implementation radicalness and other demographic variables including: type of process (job shop, batch, assembly line and continuous), type of technology (processing vs. information and decision support technology), industry (discrete vs. continuous) and plant size.

Provenness of technology

Provenness of technology refers to the degree to which an adopted technology is free of technical problems. Provenness is potentially related to temporal distance. The longer an invention has been around (temporal distance), the more likely it will have been ridden of bugs and irregularities. An invention is usually easier to implement if they have been proved and implemented since their effects on the organization are more predictable (Leonard-Barton 1988; Edmondson et al. 2003). While closely related, provenness should have an opposite effect to temporal distance on implementation performance. Thus, this study needs to control for its effect to not bias the estimation of the effect of temporal distance on performance.

Provenness was measured by asking respondents to rate on a 5-point Likert scale the degree to which a MPI invention, that they were involved in the implementation process, has been successfully adopted by other organizations.

- Before we implemented this practice/technology, its effectiveness had been demonstrated by successful adoptions in many other organizations. (strongly disagree to strongly agree)

- This practice/technology had been implemented successfully in other organizations before we adopted it. (strongly disagree to strongly agree)

Excluded items:

- Before we started the implementation process, there were known unresolved problems with the practice/technology itself. (R)
- Irregularities of this practice/technology had been resolved before we adopted it. (5-point Likert scale ranging from strongly disagree to strongly agree)

Goals Aggressiveness

This study measured performance as goals achievement. However, goals achievement is also affected by how optimistic and/or aggressive are the initial goals. While it has not been clearly argued in the past, Menon and Pfeffer's (2003) find that organizations can value external knowledge more highly than internal knowledge, partially suggesting that invention externality may be related to optimism of initial predictions (and hence the aggressiveness of the goals) of the effect it will have on the organization. Conversely, the not-invented-here syndrome (Katz and Allen 1988) can cause implementing organization to view external invention more negatively. Because of the possibility that distance to invention source may be associated with how an organization may set a goal of a project, this study explicitly measured and controlled for goal aggressiveness. In this way, its impact does not bias the effect of invention separation on implementation performance. At the same time it gives greater clarity for the rest of the findings as its effect on performance is factored out.

Aggressiveness is measured as how likely the respondents felt at the beginning of the project about the ability of the organization to achieve the goals. This study used one 5-point Likert scale question for each performance variable. The question asked the extent to which the participant agree or disagree with the following statement.

- At the start of the project, we felt the original project schedule was overly optimistic. (strongly disagree to strongly agree)
- At the start of the project, we felt the original project budget was overly optimistic. (strongly disagree to strongly agree)
- At the start of the project, we felt the original project technical goals were overly optimistic. (strongly disagree to strongly agree)

Excluded items:

- At the start of the project, we were confident that we could achieve the project budget.
- At the start of the project, we were confident that we could achieve the project schedule.
- At the start of the project, we were confident that we could achieve the project's technical goals.

Intra-team communication effectiveness

Diversity affects breadth of knowledge and access to external knowledge, but also increases communication difficulty among team members (Cohen et al. 1996; Zahra and George 2002). By controlling its negative effects through difficulty in communicating, the effect of increased breadth of knowledge due to diversity can be more clearly studied. Additionally communication effectiveness may be closely related to psychological safety since the level of psychological safety should influence team members' perception of whether communication among team members is open and encouraged.

Intra-team communication effectiveness was measured as the respondent's perception of whether communication among team members was useful, and satisfactory. The following items were modified from Earley and Mosakowski (2000) and Moenaert and Souder (1996).

- Implementation team members talked openly and freely. (strongly disagree to strongly agree)
- Implementation team members did not seem to understand what one another was saying during their discussions. (R) (strongly disagree to strongly agree)
- When implementation team members shared information it was likely to be used. (strongly disagree to strongly agree)
- Team members often shared valuable information. (strongly disagree to strongly agree)

Excluded item:

- Team members shared information in useful formats.

Implementation team size

Several reasons suggest that team size should be controlled for. Past research on group performance suggests that performance is negatively associated with team size (Gooding and Wagner III 1985). On the other hand, team size is a natural limit for functional diversity; the smaller a team is, the less functionally diverse it can be. At the same time the collective knowledge of the team which influences team's absorptive capacity undoubtedly increases with team size. Further, psychological safety may be negatively associated with team size. As the team size grows, a person may be more intimidated to voice opinions, discuss his mistake or request feedbacks. Implementation team size will be measured as how many people were in the team (Swink 2000).

- At the point in the implementation project when the number of staff was at its peak, approximately how many persons were:
  - Assigned full-time to the implementation project?
  - Assigned on a part-time basis only to the implementation project?

Project selection rigor

Project selection rigor is defined as the degree to which past experiences and existing working environment are used in selecting the project. Projects that are rigorously chosen should have goals that are more achievable and technologies that are better fit to use. The following items were modified from Iansiti (2000).

- Before choosing this practice/technology, we compared the resources that were required (e.g., tools, equipment, operators' skills) to what we had. (strongly disagree to strongly agree)
- In choosing this practice/ technology, we used detailed information on the existing user environment, product and production system. (strongly disagree to strongly agree)
- In choosing this practice/technology, we used information from past experiences in implementing new manufacturing processes. (strongly disagree to strongly agree)

Excluded items:

- Before choosing this practice/technology, we did a thorough feasibility study.
- Before choosing this practice/technology, we followed rigorous technology selection guidelines.

Implementation radicalness

Implementation radicalness is defined as the required amount of change that need to take place. Two questions capture changes required for operators of the new MPI and one for changes in tools and equipment. The measures were modified from Govindarajan and Kopalle (2006).

- In order to use the new practice/technology, the operators/users had to learn new skills and procedures. (strongly disagree to strongly agree)

- Much training was required for operators/users in order to use the new practice/technology. (strongly disagree to strongly agree)

Excluded item:

- The implementation of this practice/technology required significant changes in our assets such as tools and equipment.

Demographic variables

This study also included demographic variables that may affect the outcome of an MPI implementation project. These include type of industry (discrete vs. continuous), type of technology (communication and decision support vs. processing), environment in which the MPI was introduced to (job shop, batch, line and continuous process), scope of impact and plant size.

Type of industry was determined by the company's SIC code, and type of technology was determined by project description provided by respondents. The following were the items used for other demographic variables.

- Which of the following types of operations best describes the process that was affected by the implementation of the new practice/technology you referred to?
  - Job shop (Production of small volumes of a large number of different products)
  - Batch (Production of large volumes of similar items on a repeat basis)
  - Assembly line (Production of discrete parts moving from workstation to workstation at a controlled rate)

- Continuous flow (Processing of undifferentiated materials such as petroleum or chemicals)

- What was the scope of operations affected by this implementation? (A single work center, A production line, A department, The entire plant, Multiple plants)
- How many people are employed at the manufacturing plant where the practice/technology was implemented?

4.3 Scale reliability and validity

This section discusses the empirical testing of reliability and validity of the measures. These include testing of single response bias, unidimensionality, reliability and convergent and discriminant validity (O'Leary-Kelly and Vokurka 1998; Boyer and Verma 2000).

4.3.1 Single response bias

Single response bias or single rater bias refers to the possibility that a given response may contain "subjective bias due to an individual's unique perspective and limited access to information" (Boyer and Verma 2000). For a total of 12 projects, multiple respondents were available for eight items. Single response bias was examined by inter-rater reliability (James et al. 1984). Average inter-rater reliability is 0.694 for the eight items that are available with multiple respondents in 12 projects. The average inter-rater reliability for each item ranges from 0.47 to 0.81. This suggests that single response bias is not significant. Thus, this study used the means of the items across respondents in the analyses.

4.3.2 Construct validity

Unidimensionality and convergent and discriminant validity of the Likert scale items were tested with confirmatory factor analyses (CFA). Three separate CFA models were run for independent variables, dependent variables and control variables because of sample size limitation. Tables 4.2-4.4 report the CFA results as well as the Cronbach's alpha. Since the data exhibit multivariate non-normality (indicated by high Mardia's coefficient), generalized least squares method (GLS) in EQS was used to estimate the measurement models instead of maximum likelihood. Fit indexes in models produced by GLS estimations have been shown to be less affected by the combination of non-normal data and small sample size (West et al. 1995).

In all three models fit indices of the CFA models suggested unidimensionality of the measures. The comparative fit index (CFI) and non-normed fit index (NNFI) are both greater than 0.95, RMSEA is below 0.05 cutoff point (Hu and Bentler 1998; Hu and Bentler 1999), and GFI is above 0.90 (Hu and Bentler 1995). While NFI is below traditional cutoff point in all three models, given the small sample size and non-normality NFI may not be appropriate to use to judge model fits. NFI has been shown to underestimate its asymptotic values on non-normal data with small sample sizes (Hu and Bentler 1995).

Table 4.7 CFA results for independent variables

Construct and Measurement Items	Standardized loaings	t-value	WLJ's composite reliability	AVE	Cronbach's Alpha	(Highest factor correlation)^2
Independent variables						0.155
Physical distance	1.000					
Temporal distance	1.000					
Organizational distance	1.000					
Team's technical competence			0.704	0.442	0.692	
Team members were highly skilled.	0.660	7.434				
Team members were considered the best in the organization.	0.694	7.853				
Team members were experts in their functions.	0.640	7.349				
Team's functional diversity			0.846	0.647	0.823	
The team included people from diverse functional areas.	0.752	10.137				
Many functional areas were represented.	0.796	10.989				
The team included people from different functional groups.	0.861	12.142				
Team's psychological safety			0.761	0.445	0.705	
Mistakes were held against team members. (R)	0.658	7.782				
Team members feared bringing up problem/issues.	0.630	7.306				
No one on this team would deliberately undermine my efforts.	0.625	7.281				
Each member felt they were valuable to the team.	0.747	9.129				
NFI = .760 NNFI =.991, CFI =.994, GFI =.954, RMSEA =.009 Chi-Square =50.743 based on 50 degrees of freedom (p=.444)						

Table 4.8 CFA results for dependent variables

Construct and Measurement Items	Standardized loaings	t-value	WLJ's composite reliability	AVE	Cronbach's Alpha	(Highest factor correlation)^2
Dependent variables						0.260
Budget performance			0.758	0.534	0.714	
How much man power was actually used?	0.418	4.977				
How much capital expenditure was actually used?	0.720	8.190				
Original budget of the implementation project was met.	0.954	10.186				
Schedule performance			0.640	0.380	0.607	
How much time did the implementation actually take?	0.759	7.995				
Relative to similar projects, how long did this project take?	0.571	6.247				
How satisfied were top management with the speed?	0.487	5.401				
Technical goals achievement			0.820	0.477	0.827	
We achieved greater productivities than we originally planned	0.698	8.896				
Process quality improved more than we had expected	0.688	8.655				
Responsiveness improved more than we had hoped	0.686	8.636				
Overall improvements were better than we had expected.	0.657	8.211				
The new technology performed better than we expected.	0.724	9.509				
NFI = .801, NNFI =.989, CFI =.993, GFI =.961 , RMSEA =.012 Chi-Square =35.848 based on 35 degrees of freedom (p=.43)						

All measured variables load significantly (p<0.01) in the expected direction with the intended latent constructs. This suggests convergent validity (Bagozzi et al. 1991; O'Leary-Kelly and Vokurka 1998). The square of the correlation between any two factors is lower than average variance extracted for each of the construct in all three models. This shows that the constructs have discriminant validity (Fornell and Larcker 1981). The LM test is also not significant in the model for independent variable and the model for control variable, suggesting discriminant validity at the item level. The LM test was significant for two variables in the dependent model. However, since the performance measures were not included in any same regression model, and covariations among performance were expected, this was not a serious threat to discriminant validity. Cronbach's alpha and Werts et al.'s (Werts et al. 1974) composite reliability are all greater than 0.60 suggesting adequate reliability for the constructs (Nunnally 1967).

Construct scores were created as the weighted average of measured variables. The weights are factor loadings from the CFA models.

Table 4.9 CFA results for control variables

Construct and Measurement Items	Standardized loaings	t-value	WLJ's composite reliability	AVE	Cronbach's Alpha	(Highest factor correlation)^2
Control Variables						0.399
Provenness			0.826	0.713	0.797	
The effectiveness had been demonstrated.	1.000	17.485				
This technology had been implemented successfully before.	0.652	8.916				
Selection rigor			0.707	0.452	0.692	
Resource requirement were compared to what we had.	0.510	5.863				
Information on the existing environment was used.	0.746	8.825				
Past experiences were used.	0.734	8.829				
Implementation radicalness			0.781	0.657	0.725	
Operators/users had to learn new skills and procedures	0.561	7.349				
Much training was required for operators/users.	1.000	17.370				
Goal aggressiveness			0.687	0.429	0.617	
Original project budget was overly optimistic.	0.766	7.766				
Original project schedule was overly optimistic.	0.658	6.847				
Original project technical goals were overly optimistic.	0.517	5.675				
Intrateam communication effectiveness			0.801	0.505	0.759	
Team members talked openly and freely.	0.738	9.663				
Team members did not understand one another. (R)	0.568	6.887				
Shared information was likely to be used.	0.755	10.235				
Team members often shared valuable information.	0.764	9.808				
NFI = .748 NNFI =.980, CFI =.986, GFI =.943, AGFI =.907, RMR =.053, RMSEA =.015 Chi-Square = 67.537 based on 65 degrees of freedom (p=.391)						

Chapter 5 Analyses and Results

This chapter summarizes results of hypotheses testing via regression analyses. The variables in the regressions are factor scores based on CFA discussed at the end of Chapter 4. First, the analyses and the rationale behind each model are discussed. Next, results from the regression models are summarized.

5.1 Analyses

Ordinary least squares (OLS) hierarchical moderated regression models were run based on the hypotheses for four types of performance: budget, schedule, technical goals achievement and overall performance. As discussed in Chapter 4, two operationalizations of IID (invention-to-implementation distance) were employed. These were simple average IID and weighted average IID by percentage contribution.

Cook's distances were calculated to identify observations that may have undue influence on the estimates in the regression. As a result four observations with the highest influence were omitted from the analyses (same observations for both simple average IID, and weighted average IID analyses).

The Shapiro-Wilk test for normality of error terms from the regression models showed that the distribution of the residuals are not significantly different from the normal distribution. Breusch-Pagan test also showed no violation of the homoskedasticity assumption.

Lastly, due to the concern for multicollinearity arising from correlations among product terms, focal variables in this study were mean-centered. Tolerance and Variance inflation factors (VIF) were used to detect multicollinearity. Tolerance is a measure of how much an independent variable can be explained by all other independent variables in the model. It is calculated as $1-R^2$ of the regression of the independent variable on the rest of the independent variables. VIF, the reciprocal of tolerance, over 10 is an indication of excessive influence on standard error estimates (Neter et al. 1996). The highest VIF is 2.61 for models with simple average IID, and 3.97 for models with weighted average IID. This suggests no strong multicollinearity effect.

5.2 Results

This section summarizes findings from the regression models. Results with a priori hypotheses are reported as one-tail tests and results without a priori hypotheses as two-tail tests. All results are reported at the 0.05 level of significance. Coefficients for IID variables are expected to be negative, while coefficients for absorptive capacity-related variables and the all the interaction terms are expected to be positive (Sharma et al. 1981; Baron and Kenny 1986). Table 5.1 - Table 5.4 below provide the descriptive statistics of the variables in the regression analyses and the correlations among them.

Table 5.1 Descriptive statistics of variables for regressions with simple average

Variables	Obs	Mean	Std. Dev.	Min	Max
Budget performance	165	2.68	0.67	1.00	4.66
Schedule performance	165	2.87	0.74	1.27	5.00
Technical performance	165	3.69	0.66	1.59	5.00
Overall performance	165	3.31	0.61	1.60	4.93
Project selection rigor	165	3.92	0.60	1.00	5.00
Team size	165	2.07	0.91	0.00	5.09
Provenness	165	3.33	1.02	1.00	5.00
Communication effectiveness	165	4.01	0.49	2.26	5.00
Project goals aggressiveness	165	2.78	0.69	1.00	4.73
Physical distance (miles)	165	559.92	1225.44	0.00	8000.00
Temporal distance (years)	165	1.23	1.56	0.00	11.67
Organizational distance	165	1.93	1.27	0.00	5.00
Team's technical competence	165	3.92	0.60	2.00	5.00
Functional diversity	165	0.52	0.18	0.00	0.89
Psychological safety	165	4.01	0.67	1.52	5.00

Table 5.2 Descriptive statistics of variables for regressions with weighted average

Variables	Obs	Mean	Std. Dev.	Min	Max
Budget performance	165	2.68	0.67	1.00	4.66
Schedule performance	165	2.87	0.74	1.27	5.00
Technical performance	165	3.69	0.66	1.59	5.00
Overall performance	165	3.31	0.61	1.60	4.93
Project selection rigor	165	3.92	0.60	1.00	5.00
Team size	165	2.07	0.91	0.00	5.09
Provenness	165	3.33	1.02	1.00	5.00
Communication effectiveness	165	4.01	0.49	2.26	5.00
Project goals aggressiveness	165	2.78	0.69	1.00	4.73
Physical distance (miles)	165	330.36	980.53	0.00	8531.05
Temporal distance (years)	165	1.28	1.72	0.00	14.00
Organizational distance	165	0.80	0.84	0.00	4.00
Team's technical competence	165	3.92	0.60	2.00	5.00
Functional diversity	165	0.52	0.18	0.00	0.89
Psychological safety	165	4.01	0.67	1.52	5.00

Table 5.3 Correlations of variables for regressions with simple average

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Budget performance	1														
2. Schedule performance	0.40**	1													
3. Technical performance	0.13*	0.27**	1												
4. Overall performance	0.47**	0.51**	0.71**	1											
5. Project selection rigor	0.17**	0.11	0.29**	0.24**	1										
6. Team size	-0.01	-0.08	-0.06	-0.16**	0.07	1									
7. Provenness	-0.10	-0.10	-0.05	-0.07	0.05	-0.06	1								
8. Communication effectiveness	0.15*	0.05	0.26**	0.32**	0.44**	0.02	-0.03	1							
9. Project goals aggressiveness	-0.23**	-0.13*	0.02	-0.05	0 .00	0.04	-0.03	-0.03	1						
10. Physical distance (miles)	-0.05	-0.02	-0.05	-0.03	0.08	0.00	0.03	-0.03	0.00	1					
11. Temporal distance (years)	-0.01	-0.04	0.08	0.04	0.08	-0.03	0.12	0.13	-0.01	0.01	1				
12. Organizational distance	-0.22**	-0.21**	-0.02	-0.15*	0.10	0.04	0.07	-0.12	0.14*	0.16**	-0.01	1			
13. Team's tech competence	0.11	-0.08	0.04	0.05	0.31**	0.06	0.03	0.38**	0.02	0.04	0.00	0.05	1		
14. Functional diversity	-0.15*	0.03	0.05	-0.03	0.16**	0.21**	-0.05	-0.01	0.10	0.14*	0.12	0.10	0.12	1	
15. Psychological safety	0.19**	0.02	0.24**	0.28**	0.28**	0.05	-0.01	0.66**	-0.09	-0.02	0.12	-0.02	0.22**	-0.11	1

* $p < 0.10$
** $p < 0.05$

Table 5.4 Correlations of variables for regressions with weighted average

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Budget performance	1														
2. Schedule performance	0.40**	1													
3. Technical performance	0.13*	0.27**	1												
4. Overall performance	0.47**	0.51**	0.71**	1											
5. Project selection rigor	0.17**	0.11	0.29**	0.24**	1										
6. Team size	-0.01	-0.08	-0.06	-0.16**	0.07	1									
7. Provenness	-0.10	-0.10	-0.05	-0.07	0.05	-0.06	1								
8. Communication effectiveness	0.15*	0.05	0.26**	0.32**	0.44**	0.02	-0.03	1							
9. Project goals aggressiveness	-0.23**	-0.13*	0.02	-0.05	0.00	0.04	-0.03	-0.03	1						
10. Physical distance (miles)	0.10	0.00	-0.04	0.02	0.16**	-0.03	0.03	-0.03	0.01	1					
11. Temporal distance (years)	-0.01	-0.06	0.10	0.02	0.10	-0.01	0.09	0.11	-0.01	-0.02	1				
12. Organizational distance	-0.18**	-0.11	-0.03	-0.16**	0.17**	0.05	0.03	-0.15*	0.07	0.27**	-0.06	1			
13. Team's tech competence	0.11	-0.08	0.04	0.05	0.31**	0.06	0.03	0.38**	0.02	0.04	-0.03	0.13*	1		
14. Functional diversity	-0.15*	0.03	0.05	-0.03	0.16**	0.21**	-0.05	-0.01	0.10	0.14*	0.10	0.12	0.12	1	
15. Psychological safety	0.19**	0.02	0.24**	0.28**	0.28**	0.05	-0.01	0.66**	-0.09	-0.03	0.10	-0.09	0.22**	-0.11	1

* $p < 0.10$
** $p < 0.05$

5.2.1 Budget performance

Table 5.5 summarizes hypotheses testing results on budget performance, and Table 5.6 shows the regression results with simple average IID. Based on R-Squared, the simple average IID model for budget performance explains 23.30 percent of the variance in budget performance (12.64% based on adjusted R-squared). The hypothesis variables and their interactions account for 13.43% of the variance in budget performance (difference in adjusted R-squared = 5.61%).

Table 5.7 shows results for budget performance with weighted average IID. Based on R-Squared, the weighted average IID model for budget performance explains 27.21 percent of the variance in budget performance (17.10 percent based on adjusted R-squared). The hypothesis variables and their interactions account for 17.34% of the variance in budget performance (difference in adjusted R-squared = 10.07%).

Two project characteristic variables are found to be significant. The coefficient for project selection rigor is positive, and the coefficient for project goal aggressiveness is negative in both models. Both of these coefficients have the sign in the expected direction.

Hypothesis 1 is supported only for the effect of organizational distance on budget performance with both operationalizations of IID. Hypothesis 2a is also supported in the model with weighted average IID. There was no support for hypotheses 3a and 4a.

There was evidence in support of Hypotheses 2b and 3b but none for Hypothesis 4b. The coefficient of the interaction term temporal distance * technical competence is positive and significant in models with both simple average and weighted average IID, supporting Hypothesis 2b. The interaction term temporal distance * functional diversity has a positive and significant coefficient in both models, supporting Hypothesis 3b.

Table 5.5 Summary of hypotheses testing results for budget performance based on a one-tail test at 0.05 level of significance

Budget performance Hypotheses		Simple average IID	Weighted average IID
H1: Direct positive effect of invention-to-implementation distance (IID)	Physical distance		
	Temporal distance		
	Organizational distance	Supported	Supported
H2a: Direct positive effect of technical competence			Supported
H3a: Direct positive effect of functional diversity			
H4a: Direct positive effect of psychological safety			
H2b: Positive moderating effect of technical competence	Physical distance		
	Temporal distance	Supported	Supported
	Organizational distance		
H3b: Positive moderating effect of functional diversity	Physical distance		
	Temporal distance	Supported	Supported
	Organizational distance		
H4b: Positive moderating effect of psychological safety	Physical distance		
	Temporal distance		
	Organizational distance		

Table 5.6 Regression results for budget performance with simple average IID

Budget Performance	Beta	t		Beta	t		Beta	t		Beta	t		Beta	t	
Project selection rigor	0.14	1.63		0.18	2.08	*	0.16	1.83		0.19	2.21	*	0.17	2.00	*
Team size	-0.02	-0.25		-0.01	-0.17		0.00	0.05		0.00	0.07		0.01	0.17	
Provenness	-0.12	-1.52		-0.10	-1.33		-0.13	-1.69		-0.11	-1.53		-0.08	-1.09	
Communication effectiveness	0.08	0.95		0.04	0.51		-0.03	-0.27		-0.09	-0.84		-0.08	-0.69	
Project goals aggressiveness	-0.23	-3.02	**	-0.20	-2.69	**	-0.21	-2.77	**	-0.18	-2.43	*	-0.22	-2.90	**
Physical distance (miles)				-0.03	-0.39					-0.02	-0.20		0.01	0.08	
Temporal distance (years)				-0.03	-0.33					-0.01	-0.08		0.00	-0.01	
Organizational distance				-0.19	-2.50	**				-0.21	-2.65	**	-0.17	-2.17	*
Team's technical competence							0.08	0.95		0.09	1.15		0.08	0.94	
Functional diversity							-0.16	-2.03	*	-0.14	-1.79	*	-0.09	-1.02	
Psychological safety							0.10	1.03		0.14	1.35		0.17	1.50	
phys distance * tech competence													0.06	0.67	
temp distance * tech competence													0.15	1.73	*
org distance * tech competence													-0.02	-0.24	
phys distance * diversity													0.03	0.37	
temp distance * diversity													0.16	1.87	*
org distance * diversity													0.00	-0.05	
phys distance * psych safety													0.04	0.33	
temp distance * psych safety													0.05	0.59	
org distance * psych safety													0.03	0.33	
_cons	.	4.74		.	4.60		.	4.39		.	4.58		.	4.51	
Number of obs	165			165			165			165			165		
F(k, n-k-1)	3.48			3.10			3.02			2.93			2.19		
Prob > F	0.01			0.00			0.00			0.00			0.00		
R-squared	0.10			0.14			0.13			0.17			0.23		
Adj R-squared	0.07			0.09			0.09			0.11			0.13		
Root MSE	0.64			0.64			0.64			0.63			0.62		

* indicates p < 0.05, ** indicates p < 0.01

Table 5.7 Regression results for budget performance with weighted average IID

Budget Performance	Beta	t		Beta	t		Beta	t		Beta	t		Beta	t	
Project selection rigor	0.14	1.63		0.17	2.00	*	0.16	1.83		0.19	2.14	*	0.18	2.04	*
Team size	-0.02	-0.25		-0.01	-0.09		0.00	0.05		0.02	0.22		0.02	0.28	
Provenness	-0.12	-1.52		-0.11	-1.52		-0.13	-1.69		-0.13	-1.75		-0.11	-1.46	
Communication effectiveness	0.08	0.95		0.04	0.48		-0.03	-0.27		-0.09	-0.81		-0.07	-0.66	
Project goals aggressiveness	-0.23	-3.02	**	-0.22	-2.90	**	-0.21	-2.77	**	-0.20	-2.66	**	-0.21	-2.88	**
Physical distance (miles)				0.13	1.72	*				0.15	2.01	*	0.19	1.59	
Temporal distance (years)				-0.03	-0.39					-0.01	-0.07		0.02	0.23	
Organizational distance				-0.22	-2.74	**				-0.23	-2.92	**	-0.21	-2.50	**
Team's technical competence							0.08	0.95		0.12	1.41		0.18	2.02	*
Functional diversity							-0.16	-2.03	*	-0.17	-2.13	*	-0.09	-0.94	
Psychological safety							0.10	1.03		0.11	1.13		0.16	1.36	
phys distance * tech competence													0.11	1.24	
temp distance * tech competence													0.18	2.06	*
org distance * tech competence													0.04	0.48	
phys distance * diversity													-0.03	-0.19	
temp distance * diversity													0.22	2.58	**
org distance * diversity													0.06	0.65	
phys distance * psych safety													0.02	0.20	
temp distance * psych safety													0.13	1.36	
org distance * psych safety													-0.01	-0.08	
_cons	.	4.74		.	4.79		.	4.39		.	4.70		.	4.53	
Number of obs	165			165			165			165			165		
F(k, n-k-1)	3.48			3.36			3.02			3.26			2.69		
Prob > F	0.01			0.00			0.00			0.00			0.00		
R-squared	0.10			0.15			0.13			0.19			0.27		
Adj R-squared	0.07			0.10			0.09			0.13			0.17		
Root MSE	0.64			0.63			0.64			0.62			0.61		

* indicates $p < 0.05$

** indicates $p < 0.01$

5.2.2 Schedule performance

Table 5.8 summarizes hypotheses testing results on schedule performance. Table 1.9 shows the regression results with simple average IID. The simple average IID model explains 15.30 percent of the variance in schedule performance (adjusted R-squared = 3.54). The hypothesis variables and their interactions account for 10.65% of the variance in schedule performance (difference in adjusted R-squared = 1.89%).

Table 5.10 shows the regression results on schedule performance with weighted average IID. The weighted average IID model explains 16.15 percent of the variance in schedule performance (adjusted R-squared = 4.50%). The hypothesis variables and their interactions account for 11.50% of the variance in schedule performance (difference in adjusted R-squared = 2.85%).

For both operationalizations of IIF, the F-test is not significant at the 0.05 level of significance, but some of the individual coefficients are significant with evidence supporting some of the hypotheses.

One project characteristic variable, Project selection rigor, is positive and significant. There is support for Hypothesis 1, but only for the effect of organizational IID in the simple average IID model. Hypotheses 2a and 4a are not supported. Hypothesis 3a is supported with a positive and significant for functional diversity in the model with weighted average IID. There is no evidence in support of Hypothesis 2b, but there is support for Hypotheses 3b and 4b in the model with weighted average IID. The interaction terms temporal distance * functional diversity and temporal distance * psychological safety both have a positive and significant coefficient.

Table 5.8 Summary of hypotheses testing results for schedule performance based on a one-tail test at 0.05 level of significance

Schedule performance		Simple average IID	Weighted average IID
Hypotheses			
H1: Direct positive effect of invention-to-implementation distance (IID)	Physical distance		
	Temporal distance		
	Organizational distance	Supported	
H2a: Direct positive effect of technical competence			
H3a: Direct positive effect of functional diversity			Supported
H4a: Direct positive effect of psychological safety			
H2b: Positive moderating effect of technical competence	Physical distance		
	Temporal distance		
	Organizational distance		
H3b: Positive moderating effect of functional diversity	Physical distance		
	Temporal distance		Supported
	Organizational distance		
H4b: Positive moderating effect of psychological safety	Physical distance		
	Temporal distance		Supported
	Organizational distance		

Table 5.9 Regression results for schedule performance with simple average IID

Schedule Performance	Beta	t		Beta	t		Beta	t		Beta	t		Beta	t	
Project selection rigor	0.12	1.39		0.16	1.81		0.13	1.48		0.16	1.84		0.15	1.65	
Team size	-0.09	-1.12		-0.08	-1.06		-0.09	-1.11		-0.09	-1.13		-0.11	-1.31	
Provenness	-0.11	-1.44		-0.10	-1.23		-0.11	-1.35		-0.09	-1.11		-0.07	-0.86	
Communication effectiveness	-0.01	-0.10		-0.04	-0.51		0.06	0.50		0.00	0.00		-0.02	-0.14	
Project goals aggressiveness	-0.13	-1.67		-0.10	-1.33		-0.13	-1.68		-0.11	-1.35		-0.10	-1.27	
Physical distance (miles)				0.01	0.07					0.00	0.03		-0.03	-0.36	
Temporal distance (years)				-0.04	-0.54					-0.06	-0.73		-0.08	-0.88	
Organizational distance				-0.21	-2.63	**				-0.21	-2.54	**	-0.18	-2.15	*
Team's technical competence							-0.13	-1.47		-0.11	-1.35		-0.06	-0.61	
Functional diversity							0.04	0.53		0.07	0.81		0.11	1.17	
Psychological safety							-0.03	-0.32		0.00	0.01		-0.06	-0.53	
phys distance * tech competence													0.08	0.87	
temp distance * tech competence													0.04	0.48	
org distance * tech competence													0.08	0.85	
phys distance * diversity													0.00	0.05	
temp distance * diversity													0.12	1.35	
org distance * diversity													0.07	0.74	
phys distance * psych safety													-0.15	-1.39	
temp distance * psych safety													0.07	0.77	
org distance * psych safety													0.02	0.25	
_cons	.	5.15		.	5.00		.	3.40		.	3.52		.	3.56	
Number of obs	165			165			165			165			165		
F(k, n-k-1)	1.55			1.91			1.27			1.59			1.30		
Prob > F	0.18			0.06			0.26			0.11			0.19		
R-squared	0.05			0.09			0.06			0.10			0.15		
Adj R-squared	0.02			0.04			0.01			0.04			0.04		
Root MSE	0.74			0.73			0.74			0.73			0.73		

* indicates $p < 0.05$, ** indicates $p < 0.01$

Table 5.10 Regression results for schedule performance with weighted average IID

Schedule Performance	Beta	t		Beta	t		Beta	t		Beta	t		Beta	t	
Project selection rigor	0.12	1.39		0.16	1.78		0.13	1.48		0.17	1.81		0.20	2.09	*
Team size	-0.09	-1.12		-0.08	-1.06		-0.09	-1.11		-0.09	-1.11		-0.10	-1.22	
Provenness	-0.11	-1.44		-0.10	-1.34		-0.11	-1.35		-0.10	-1.23		-0.08	-0.93	
Communication effectiveness	-0.01	-0.10		-0.04	-0.42		0.06	0.50		0.02	0.20		0.02	0.14	
Project goals aggressiveness	-0.13	-1.67		-0.12	-1.56		-0.13	-1.68		-0.13	-1.60		-0.12	-1.54	
Physical distance (miles)				0.01	0.18					0.01	0.07		-0.10	-0.75	
Temporal distance (years)				-0.08	-0.96					-0.09	-1.13		-0.12	-1.31	
Organizational distance				-0.14	-1.67	*				-0.12	-1.45		-0.10	-1.09	
Team's technical competence							-0.13	-1.47		-0.12	-1.32		-0.03	-0.29	
Functional diversity							0.04	0.53		0.06	0.73		0.21	1.90	*
Psychological safety							-0.03	-0.32		-0.02	-0.21		-0.01	-0.05	
phys distance * tech competence													0.09	1.02	
temp distance * tech competence													0.08	0.89	
org distance * tech competence													0.07	0.74	
phys distance * diversity													0.14	0.89	
temp distance * diversity													0.17	1.94	*
org distance * diversity													0.14	1.33	
phys distance * psych safety													-0.05	-0.46	
temp distance * psych safety													0.17	1.73	*
org distance * psych safety													0.10	0.93	
_cons	.	5.15		.	4.97		.	3.40		.	3.37		.	3.03	
Number of obs	165			165			165			165			165		
F(k, n-k-1)	1.55			1.42			1.27			1.22			1.39		
Prob > F	0.18			0.19			0.26			0.28			0.14		
R-squared	0.05			0.07			0.06			0.08			0.16		
Adj R-squared	0.02			0.02			0.01			0.01			0.05		
Root MSE	0.74			0.73			0.74			0.74			0.72		

* indicates $p < 0.05$

** indicates $p < 0.01$

5.2.3 Technical performance

Table 5.11 summarizes hypotheses testing results for technical performance. Table 5.12 shows the results for technical performance with simple average IID. The simple average IID model explains 20.44 percent of the variance in technical performance (adjusted R-squared = 9.39%). The hypothesis variables and their interactions account for 9.02% of the variance in technical performance (difference in adjusted R-squared = 0.76%).

Table 5.13 shows technical performance results with weighted average IID. The weighted average IID model explains 23.98 percent of the variance (adjusted R-squared = 13.43%). The hypothesis variables and their interactions explain 12.56% of the variance in technical performance (difference in adjusted R-squared = 4.80%).

Only one project characteristic variable, project selection rigor, is significantly related to technical performance. The relationship is positive in the simple average model. There is no support for Hypotheses 1, 2a or 3a in technical performance. Hypothesis 4a is supported in the model with weighted average IID.

There is some evidence supporting Hypothesis 2b with both operationalizations of IID. The interaction term temporal distance * technical competence is positive and significant. Hypotheses 3b and 4b, however, are not supported by either operationalization. In fact there is evidence opposing Hypothesis 4b. The coefficient for the interaction term organizational distance * psychological safety is negative and significant in both models (two-tail p = 0.015, 0.034).

Table 5.11 Summary of hypotheses testing results for technical performance based on a one-tail test at 0.05 level of significance

Technical performance Hypotheses		Simple average IID	Weighted average IID
H1: Direct positive effect of invention-to-implementation distance (IID)	Physical distance		
	Temporal distance		
	Organizational distance		
H2a: Direct positive effect of technical competence			
H3a: Direct positive effect of functional diversity			
H4a: Direct positive effect of psychological safety			Supported
H2b: Positive moderating effect of technical competence	Physical distance		
	Temporal distance	Supported	Supported
	Organizational distance		
H3b: Positive moderating effect of functional diversity	Physical distance		
	Temporal distance		
	Organizational distance		
H4b: Positive moderating effect of psychological safety	Physical distance		
	Temporal distance		
	Organizational distance	Opposed	Opposed

Table 5.12 Regression results for technical performance with simple average IID

Technical Performance	Beta	t		Beta	t		Beta	t		Beta	t		Beta	t	
Project selection rigor	0.22	2.65	**	0.23	2.67	**	0.23	2.66	**	0.23	2.70	**	0.20	2.28	*
Team size	-0.08	-1.11		-0.08	-1.09		-0.10	-1.26		-0.10	-1.26		-0.10	-1.28	
Provenness	-0.06	-0.75		-0.06	-0.80		-0.05	-0.70		-0.05	-0.72		-0.09	-1.11	
Communication effectiveness	0.16	1.97		0.15	1.76		0.11	0.97		0.09	0.81		0.11	0.96	
Project goals aggressiveness	0.03	0.41		0.03	0.42		0.04	0.51		0.04	0.52		0.05	0.64	
Physical distance (miles)				-0.07	-0.85					-0.07	-0.89		-0.05	-0.60	
Temporal distance (years)				0.05	0.69					0.03	0.43		0.06	0.66	
Organizational distance				-0.01	-0.08					-0.01	-0.18		-0.03	-0.31	
Team's technical competence							-0.10	-1.23		-0.09	-1.13		-0.09	-1.01	
Functional diversity							0.06	0.77		0.07	0.81		0.01	0.08	
Psychological safety							0.14	1.42		0.14	1.41		0.13	1.17	
phys distance * tech competence													-0.03	-0.35	
temp distance * tech competence													0.16	1.82	*
org distance * tech competence													0.07	0.74	
phys distance * diversity													-0.10	-1.11	
temp distance * diversity													-0.11	-1.30	
org distance * diversity													-0.03	-0.40	
phys distance * psych safety													-0.01	-0.06	
temp distance * psych safety													0.05	0.56	
org distance * psych safety													-0.23	-2.47	**
_cons	.	3.84		.	3.85		.	3.39		.	3.42		.	3.54	
Number of obs	165			165			165			165			165		
F(k, n-k-1)	4.10			2.69			3.05			2.29			1.85		
Prob > F	0.00			0.01			0.00			0.01			0.02		
R-squared	0.11			0.12			0.14			0.14			0.20		
Adj R-squared	0.09			0.08			0.09			0.08			0.09		
Root MSE	0.63			0.64			0.63			0.63			0.63		

* indicates $p < 0.05$

** indicates $p < 0.01$

Table 5.13 Regression results for technical performance with weighted average IID

Technical Performance	Beta	t		Beta	t		Beta	t		Beta	t		Beta	t	
Project selection rigor	0.22	2.65	**	0.24	2.73	**	0.23	2.66	**	0.24	2.75	**	0.16	1.82	
Team size	-0.08	-1.11		-0.08	-1.12		-0.10	-1.26		-0.10	-1.29		-0.11	-1.49	
Provenness	-0.06	-0.75		-0.06	-0.81		-0.05	-0.70		-0.06	-0.73		-0.08	-1.10	
Communication effectiveness	0.16	1.97		0.14	1.64		0.11	0.97		0.09	0.76		0.13	1.15	
Project goals aggressiveness	0.03	0.41		0.03	0.44		0.04	0.51		0.04	0.53		0.04	0.52	
Physical distance (miles)				-0.07	-0.87					-0.08	-0.97		-0.06	-0.44	
Temporal distance (years)				0.07	0.86					0.05	0.61		0.08	0.94	
Organizational distance				-0.03	-0.32					-0.02	-0.21		0.04	0.43	
Team's technical competence							-0.10	-1.23		-0.09	-1.09		-0.14	-1.57	
Functional diversity							0.06	0.77		0.07	0.81		0.02	0.23	
Psychological safety							0.14	1.42		0.14	1.40		0.22	1.90	*
phys distance * tech competence													-0.02	-0.26	
temp distance * tech competence													0.20	2.22	*
org distance * tech competence													-0.15	-1.64	
phys distance * diversity													-0.01	-0.09	
temp distance * diversity													0.02	0.20	
org distance * diversity													0.02	0.21	
phys distance * psych safety													0.04	0.34	
temp distance * psych safety													0.09	0.91	
org distance * psych safety													-0.21	-2.15	*
_cons	.	3.84		.	3.85		.	3.39		.	3.41		.	3.73	
Number of obs	165			165			165			165			165		
F(k, n-k-1)	4.10			2.78			3.05			2.34			2.27		
Prob > F	0.00			0.01			0.00			0.01			0.00		
R-squared	0.11			0.12			0.14			0.14			0.24		
Adj R-squared	0.09			0.08			0.09			0.08			0.13		
Root MSE	0.63			0.63			0.63			0.63			0.62		

* indicates $p < 0.05$

** indicates $p < 0.01$

5.2.4 Overall performance

Table 5.14 summarizes importance weight the participants assigned to each type of performance that are used to calculate overall performance. On average about half of the weight is assigned to technical performance.

Table 5.14 Summary of importance weight assigned to each category of performance

Variables	Obs	Mean	Std. Dev.	Min	Max
Budget weight (%)	169	22.92	15.35	0.00	80.00
Schedule weight (%)	169	26.92	18.75	0.00	90.00
Technical achievement weight (%)	169	51.46	22.77	10.00	100.00

Table 5.15 provides the summary of the hypotheses testing results on overall performance. Table 5.16 provides regression results for overall performance with simple average IID. The simple average IID model explains 26.60 percent of variance in overall performance (adjusted R-squared = 16.41%). The main variables and their interactions account for 11.29% of the variance in overall performance (difference in adjusted R-squared = 3.76%).

The results for overall performance with weighted average IID are provided in Table 5.17. The variables in the weighted average IID model account for 28.60% (adjusted R-squared = 18.69%). The main variables and their interactions account for 13.29% of the variance in overall performance (difference in adjusted R-squared = 6.04%).

Only one project characteristic variable, team size, is significantly related to overall performance. Its relationship is negative. There is no support for

Hypotheses 1, 2a and 3a. Hypothesis 4a for the direct positive effect of psychological safety is supported in both models of IID.

There is support for Hypothesis 2b in both operationalizations of IID. The interaction term temporal distance * technical competence has a significant positive coefficient. Hypothesis 3b is supported with the significant positive coefficient of the interaction term temporal distance * functional diversity in the model with weighted average IID. Lastly, there is also evidence supporting Hypothesis 4b. The coefficient of the interaction term temporal distance * psychological safety is positive and significant with weighted average IID.

Table 5.15 Summary of hypotheses testing results for overall performance based on a one-tail test at 0.05 level of significance

Overall performance		Simple average IID	Weighted average IID
Hypotheses			
H1: Direct positive effect of invention-to-implementation distance (IID)	Physical distance		
	Temporal distance		
	Organizational distance		
H2a: Direct positive effect of technical competence			
H3a: Direct positive effect of functional diversity			
H4a: Direct positive effect of psychological safety		Supported	Supported
H2b: Positive moderating effect of technical competence	Physical distance		
	Temporal distance	Supported	Supported
	Organizational distance		
H3b: Positive moderating effect of functional diversity	Physical distance		
	Temporal distance		Supported
	Organizational distance		
H4b: Positive moderating effect of psychological safety	Physical distance		
	Temporal distance		Supported
	Organizational distance		

Table 5.16 Regression results for overall performance with simple average IID

Overall Performance	Beta	t		Beta	t		Beta	t		Beta	t		Beta	t	
Project selection rigor	0.15	1.83		0.17	2.07	*	0.16	1.95		0.18	2.17	*	0.15	1.77	
Team size	-0.18	-2.47	*	-0.18	-2.41	*	-0.19	-2.48	*	-0.19	-2.47	*	-0.18	-2.45	*
Provenness	-0.08	-1.11		-0.07	-1.00		-0.08	-1.09		-0.07	-0.96		-0.07	-0.91	
Communication effectiveness	0.25	3.07	**	0.23	2.70	**	0.19	1.73		0.15	1.32		0.16	1.45	
Project goals aggressiveness	-0.04	-0.53		-0.02	-0.31		-0.03	-0.37		-0.01	-0.14		-0.01	-0.13	
Physical distance (miles)				-0.01	-0.15					-0.01	-0.14		0.01	0.11	
Temporal distance (years)				0.00	0.01					-0.01	-0.17		-0.01	-0.09	
Organizational distance				-0.12	-1.60					-0.13	-1.71	*	-0.10	-1.22	
Team's technical competence							-0.09	-1.08		-0.08	-0.95		-0.07	-0.77	
Functional diversity							0.01	0.16		0.02	0.31		0.02	0.26	
Psychological safety							0.14	1.42		0.16	1.62		0.19	1.71	*
phys distance * tech competence													-0.06	-0.76	
temp distance * tech competence													0.22	2.53	**
org distance * tech competence													0.10	1.17	
phys distance * diversity													-0.07	-0.83	
temp distance * diversity													0.04	0.44	
org distance * diversity													0.05	0.61	
phys distance * psych safety													0.01	0.13	
temp distance * psych safety													0.13	1.47	
org distance * psych safety													-0.12	-1.34	
_cons	.	4.23		.	4.12		.	3.69		.	3.76		.	3.82	
Number of obs	165			165			165			165			165		
F(k, n-k-1)	5.75			3.93			4.01			3.20			2.61		
Prob > F	0.00			0.00			0.00			0.00			0.00		
R-squared	0.15			0.17			0.17			0.19			0.27		
Adj R-squared	0.13			0.13			0.13			0.13			0.16		
Root MSE	0.57			0.57			0.57			0.57			0.55		

* indicates $p < 0.05$, ** indicates $p < 0.01$

Table 5.17 Regression results for overall performance with weighted average IID

Overall Performance	Beta	t		Beta	t		Beta	t		Beta	t		Beta	t	
Project selection rigor	0.15	1.83		0.19	2.22	*	0.16	1.95		0.20	2.27	*	0.16	1.78	
Team size	-0.18	-2.47	*	-0.18	-2.39	*	-0.19	-2.48	*	-0.18	-2.44	*	-0.18	-2.49	*
Provenness	-0.08	-1.11		-0.08	-1.07		-0.08	-1.09		-0.08	-1.05		-0.07	-0.99	
Communication effectiveness	0.25	3.07	**	0.21	2.55	*	0.19	1.73		0.14	1.27		0.17	1.59	
Project goals aggressiveness	-0.04	-0.53		-0.03	-0.40		-0.03	-0.37		-0.02	-0.26		-0.01	-0.16	
Physical distance (miles)				0.03	0.43					0.03	0.39		0.02	0.13	
Temporal distance (years)				-0.03	-0.36					-0.04	-0.51		-0.02	-0.27	
Organizational distance				-0.16	-1.98	*				-0.15	-1.87	*	-0.10	-1.19	
Team's technical competence							-0.09	-1.08		-0.07	-0.80		-0.08	-0.86	
Functional diversity							0.01	0.16		0.02	0.27		0.07	0.73	
Psychological safety							0.14	1.42		0.15	1.51		0.25	2.17	*
phys distance * tech competence													-0.06	-0.64	
temp distance * tech competence													0.19	2.18	*
org distance * tech competence													-0.04	-0.42	
phys distance * diversity													0.01	0.07	
temp distance * diversity													0.16	1.89	*
org distance * diversity													0.14	1.44	
phys distance * psych safety													0.06	0.50	
temp distance * psych safety													0.15	1.69	*
org distance * psych safety													-0.11	-1.17	
_cons	.	4.23		.	4.16		.	3.69		.	3.76		.	3.70	
Number of obs	165			165			165			165			165		
F(k, n-k-1)	5.75			4.11			4.01			3.26			2.88		
Prob > F	0.00			0.00			0.00			0.00			0.00		
R-squared	0.15			0.17			0.17			0.19			0.29		
Adj R-squared	0.13			0.13			0.13			0.13			0.19		
Root MSE	0.57			0.56			0.57			0.56			0.55		

* indicates $p < 0.05$

** indicates $p < 0.01$

Chapter 6 Discussion and conclusion

This chapter concludes the study with the discussion of the findings and theoretical contributions, managerial implications, and ends with limitations and suggestions for future research.

6.1 Findings and theoretical contributions

Control variables

Five control variables were included in the regression models. There is evidence that project selection rigor has a positive relationship with budget, schedule and technical performance, but not with overall performance (the relationship is positive with two-tail p =0.075 in both models). This means that a technology/practice that is chosen based on information from past experiences and existing user environment tends to require less resources and time and achieve better technical performance.

Team size has a negative effect on overall performance, but it does not have significant effect on any of the individual performance score. The results confirm findings in the management literature prior to 1985 (Gooding and Wagner III 1985) that as team size grows, efficiency-based group performance, the focus of this study, tend to be lower. This is explained as the effect of higher social distraction, greater coordination requirements, more behavioral masking and diffusion of responsibility (Wagner III and Hollenbeck 1992). The results contradict findings in a recent meta-analytic review on project team size (Stewart 2006). However, Stewart (2006) does not distinguish between different types of performance measure (output vs. efficiency) which may bias the finding. The explanation given for the more recent finding is that larger teams/organizations are more able to obtain resources such as personnel and money.

Goal aggressiveness is negatively associated with budget performance, but not associated with other performance. The fact that aggressiveness is not associated with schedule and technical performance is interesting, because it suggests that schedule and technical achievement are more difficult to predict, and that initial goals' aggressiveness do not explain much of the variance in performance score.

Provenness of technology and intra-team communication effectiveness are not related with any of the performance measures. The lack of significance for the relationship between provenness and implementation performance is surprising, since a proven technology's effects on an organization are more predictable (Leonard-Barton 1988; Edmondson et al. 2003). Another interesting observation is that provenness is positively but not significantly associated with temporal distance. The lack of significant relationships between communication effectiveness and implementation performance may be explained by the high correlation (r=0.66) between communication effectiveness and psychological safety.

Invention-to-implementation distance (IID)

This study extends the literature by explicitly measuring and testing the IID construct. Previous studies on this topic have used this variable as a dichotomy of internal and external to the organization. This study recognized that more than one party could contribute to the design of a manufacturing process innovation (MPI), and that IID is composed of three distance dimensions. This study accounted for those MPIs that were collaboratively invented and measured the dimensions of IID accordingly. It also tested the hypotheses of direct effect of IID on MPI implementation project performance.

The results of this study imply that organizational distance is the only aspect of IID that has a significant negative effect on implementation performance, and this is true for budget and schedule performance only. The results suggest that physical distance between an MPI source and the implementation site does not introduce any barrier in implementing an MPI. Temporal distance does not have a significant direct relationship on performance either, but it has a moderating effect which will be discussed further.

The findings on organizational distance are contrary to what would be suggested by prior findings (Menon and Pfeffer 2003, and Menon et al.2006). Menon and coauthors find that organizations are likely to resist internal innovations and welcome external innovations for fear of internal competitions. Szulanski's (2004) results indicate that although cultural difference between the invention source and the recipient results in lower recipient's motivation to implement the invention, it has a overall positive effect on knowledge transfer process ease. The findings of this study might indicate that how an organization values a set of knowledge (which feeds into motivation) and cultural difference between the source and the recipient organizations may not be as significant factors in determining the success of a manufacturing process implementation project.

The results of the present study on organizational distance conform with Fedor et al.'s (2003) finding. Fedor et al. (2003) find that internal knowledge generation has a positive impact on integrated product and process development project performance, while external knowledge generation has no significant effect. The findings indicate that the origin of knowledge matters, and knowledge from a more distant source has lower benefit on project performance. Fedor et al.'s (2003) finding implicitly suggests that distance has a negative effect on project performance.

Team members' technical competence

The study provides an empirical test of the application of the absorptive capacity framework in the context of manufacturing process implementations. Technical competence of the team members, measured as perception of team members' skill and expertise, is found to be positively associated with budget performance, but no other type of performance. Technical competence of implementation project team members is expected to be positively related with the team's absorptive capacity which is critical in the implementation activities (Cohen and Levinthal 1990; Zahra and George 2002).

It is surprising that technical competence is positively related to only one of the four performance scales. Subramaniam and Youndt's (2003) finding provides an explanation for the lack of support in three of the four performance scales in the present study. The authors find that technical competence alone can negatively affect an organization's ability to radically innovate, an absorptive capacity. In addition, organization members' technical competence needs to be coupled with social interaction among the members to be beneficial.

Functional diversity

The results indicate a significant positive relationship between functional diversity and schedule performance but no significant relationship with other performances. Functional diversity was expected to have a positive effect on implementation project performance because more perspectives allows the team to anticipate, detect and solve more potential problems. This finding supports the evidence found in the project management literature (e.g., Sen and Rubenstein 1989 and Pinto et al. 1993).

Similarly to the finding on technical competence, it is surprising that functional diversity is positively related to only one performance scale, schedule performance. A possible explanation is that the effect of functional diversity is not linear. The absorptive capacity literature (Cohen and Levinthal 1990) suggests that diversity has a positive relationship with an organization's absorptive capacity, but the positive effect diminishes and may even be negative as diversity makes communication among team members difficult.

Psychological safety

The results of this study provide additional support for Edmondson et al.'s (2001) findings on technical performance, as well as extends the testing on project budget and schedule performance. This study uses a relatively large sample size (N = 51 for Edmondson and co-authors and N = 47 for Baer and Freese (2003)), thus, provides greater statistical power in testing the theory.

The results of this study show that psychological safety is not significantly related to budget and schedule performance but has a positive relationship with technical and overall performance. Psychological safety has been shown to enhance the team's ability to learn, and thus was expected to be positively associated with implementation performance.

Team psychological safety is argued to result in greater exercising of effective team learning behaviors. The effect of these behaviors may be more direct on technical performance as technical performance is directly driven by the "quality" of the learning, solutions to problem and newly created procedures to accompany the implemented practice/technology. Effective learning behaviors should also be beneficial to lower the implementation cost and duration. However, budget and schedule performance may be more highly influenced by other factors such as the relative importance of each of the goals in the project.

Moderating effect of technical competence

There is a positive interaction effect between technical competence and temporal distance on budget, technical and overall performance. However, the main effect of temporal distance is not significant in any of the models and the main effect of technical competence is only significant in the budget performance model. Thus, the results should be reinterpreted (Sharma et al. 1981; Baron and Kenny 1986). The results imply that when an MPI is from a temporally distant source, team members' technical competence actually has a greater positive effect on budget performance. In technical and overall performance the interrelationships between technical competence and temporal distance are not clear since neither main effect is significant.

The results suggest that absorptive capacity is more valuable at a high level of IID where there tends to be greater requirements to learn and solve problems. (Another possible interpretation, which is not as plausible, is that at high level of IID, technical competence creates greater absorptive capacity.)

Moderating effect of functional diversity

The coefficient for the interaction term between temporal distance and functional diversity is positive and significant in budget, schedule and overall performance. The interrelationships between functional diversity and temporal distance on budget and overall performance is not clear, since the main effects of both variables are not significant in either of the models. In the schedule performance model, the main effect of functional diversity is positive and significant while the main effect of temporal distance is not. The result, thus, indicates that temporal distance is a positive moderator of the relationship between functional diversity and schedule performance. The longer an invention has been designed, the higher the benefit of functional diversity will be on finishing the MPI implementation process on schedule.

The overall message is that functional diversity, and thus absorptive capacity, has higher value in MPI implementation projects where designs are older. Since there is greater requirement for learning and problem solving for an MPI with a more temporally distant source, this means that functional diversity is more valuable when there is greater learning and problem requirement.

Moderating effect of psychological safety

Only one of interaction term between psychological safety and IID variable, psychological safety*temporal distance, has a significant and positive coefficient in the overall performance model. The result suggests that psychological safety is more valuable with higher temporal IID.

However, the coefficient for the interaction between psychological safety and organizational distance is negative and significant in the technical performance model. This suggests that psychological safety is less valuable when organizational IID is high. The result is puzzling and there is no plausible theoretical argument at this point. Replication of this study in the same and different context will be worthwhile.

Comparisons between the two operationalizations of IID

In this study two operationalizations of IID were used. One was a simple average distance, and the other is weighted average distance. The simple average distance has an advantage that it is free of further assumption of how each distance should be weighted. The weighted average distance assumes that difficulty arising from distance for each source is proportionate to the contribution of the source.

The results in all four categories of performance show that weighted average IID models explain more variance in performance than respective simple average IID models. This is an evidence that difficulty of distance that the MPI implementing unit faces from each source is somewhat proportionate to the source's contribution to the project. A recommendation for future studies on the measurement of this variable is discussed in the last section of the chapter.

6.2 Managerial implications

The results of this study should aid managers in outsourcing decisions as well as managing the implementation process. First, managers must increase awareness of the potential negative effect when making outsourcing/off-shoring decisions along with other effects that have been documented (increasing dependence, moving away from competency in the technological invention). The results of this study show that increasing organizational distance between an MPI source and the implementing organization results in worse budget performance.

Second, staffing and team characteristics have significant effects on whether a project will achieve its goals. Technical competence and functional diversity of the implementation team members alone may not significantly result in better project performance. The results of this study combined with past research may suggest that their effect is contingent on task uncertainty and level of communication among team members. Moreover, their benefits are contingent on the level of temporal IID. At high level of temporal IID, technical competence and functional diversity are more positively associated with implementation performance.

Lastly, psychological safety among team members has positive effect on technical and overall performance. While it may be difficult to encourage, it can be fostered by selection of leaders and team members that may exhibit certain characteristics. These include people who encourage others to take risk, and people that realize that making mistakes is sometimes necessary for learning during an implementation process.

6.3 Directions for future research

Studies on innovation implementation are still relatively scarce. Large-scale empirical studies should be conducted in different project contexts to illustrate the robustness of the findings here. In addition, there are certain limitations for the current study that future studies should address. Two specific theoretical issues and three methodological issues are discussed.

First, a major limitation for this study is that the models explain relatively low level of variance in the dependent variables. This suggests that some key variables and interactions relationships may be missing. This is especially true with interactions between issues from operations management and organization behaviors as noted by Repenning and Sterman (2002). The following lists specific issues that should be included in future studies.

- Resource availability. Many project management studies have found top management commitment to the project as a success factor. Top management commitment is likely to be a proxy for resource availability. Including some measure of resource availability should enhance the explanation power of the model as well as explicitly control for variance in performance due to resource availability.
- Contingency perspective with respect to degree of change required. The works by Tyre and Hauptman (1992), Shenhar et al. (2002) and Stock and Tatikonda (Forthcoming in JOM) suggest that the value of variables such as technical competence and functional diversity may be contingent on degree of radicalness. The inclusion of interactions with radicalness should enhance the understanding of the relationships among the variables under investigation here.
- Contingency perspective with respect to communication among members. Subramaniam and Youndt's (2005) findings suggest that the value of organization members' skills and expertise is contingent on the level of communication among themselves. This suggests that the interactions between technical competence,

psychological and communication effectiveness may have significant effect on project performance.

- Interactions among the preconditions of absorptive capacity. Preconditions for absorptive capacity such as breadth and depth of knowledge and linkage among organizational members (Cohen and Levinthal 1990; Zahra and George 2002; Smith et al. 2005) may have reinforcing effects with one another. Future research should investigate the interactions among these variables and their effect on absorptive capacity.

Second, the hypotheses of this study are based on the argument that IID results in lower fit (culturally and physically) between existing work environment and the MPI. The lack of physical and cultural fit results in greater required change that induces greater learning requirement, and possibly resistance behaviors (caused by lower motivation due to preference for stability). This study did not include these mediating variables. Explicitly measuring and integrating these variables into the framework will enhance the understanding of the dynamics of the implementation process.

The first methodological issue is that this study measures performance as goal achievement and control for goal aggressiveness. Both of these are perceptual variables that may not accurately reflect the true level of accomplishment of a project. However, this was necessary to make performance ratings comparable across projects. Future study should explore other operationalizations of performance that can circumvent the incomparability of performance across projects.

Secondly, the measurement of IID in this study assumes that difficulty arising from distance for each source is proportionate to the contribution of the source. An alternative way to measure the weight, that removes the necessity of this assumption, is to directly measure the level of communication to each of the sources. This should be further considered for future studies.

Finally, this study employed a cross-sectional data that captures the information after the implementation had been completed. Reported information on the implementation process may have been distorted by the respondent's awareness of the project's performance. Longitudinal study that captures information on each project at multiple points in time will eliminate the hindsight effect.

Appendix 1 Final round Q-sort

Table A1 Instructions for Q-sort

First, please read each of the 8 factor definitions below. 34 statements related to these factors are listed to the right of this cell. Please place a "1" in the row below each statement that indicates the factor to which that statement is most closely related.
Invention innovativeness: The degree to which the original design of the manufacturing practice/technology that we adopted was new to the world.
Implementation change required The degree to which our systems, skills, procedures, or equipment had to be changed in order to implement the new practice/technology.
Provenness of technology: The degree to which the new manufacturing practice/ technology was well understood and free from malfunctions before we adopted it.
Project selection rigor: When we first selected the practice/technology, the degree to which we considered its fitness and feasibility for our situation.
Project team technical competence: The combined quality and depth of useful knowledge that was represented by persons on the implementation team.
Project team diversity: The extent to which multiple functions were represented on the implementation team.
Effectiveness of intra-team communication: The usefulness of communications among implementation team members.
Psychological safety: The shared belief among implementation team members that it was safe to take personal risks.
Cost performance: The degree to which expenses for the implementation project adhered to the initial planned budget of the project
Technical goals achievement: The degree to which the performance of the new practice/technology matched the original operational improvement targets of the project (e.g., improving production quality, time or cost)
On-time performance: The degree to which the timing and completion of the implementation project adhered to the initial planned project schedule

Table A2 Final Round Q-sort Correct Placement Ratio

Construct	Questionnaire item	% Correctly sorted
Effectiveness of intra-team communication	People on the implementation team talked openly and freely.	91.89
	Team members shared information in useful formats.	89.19
	Implementation team members did not seem to understand what one another was saying during their discussions. (R)	94.59
	Team members often shared valuable information.	78.38
	When implementation team members shared information it was likely to be used.	67.57
Psychological safety	It was safe to take a risk on this team.	91.89
	If an implementation team member made a mistake, it was held against them. (R)	64.86
	People on the team were often afraid to ask other members for help. (R)	24.32
	Team members feared that bringing up problems/issues would have negative effects on their career prospects. (R)	70.27
	Competition among team members sometimes suppressed individual contributions to the team. (R)	37.84
	People on this team sometimes rejected other members. (R)	43.24
	Each of the members of the implementation team felt that they were valuable to the team.	48.65
Cost performance	The actual implementation cost was significantly more than the original budget. (R)	100.00
	Significantly more capital expenditure than originally planned was used in the implementation. (R)	100.00
	Significantly more manpower was used in the implementation than originally planned. (R)	48.65
Technical goals achievement	The new practice/technology performed significantly better than we originally expected.	94.59
	The new practice/technology improved our responsiveness more than we had hoped.	86.49
	The new practice/technology improved the quality of our process more than we had originally expected it would.	97.30
	The new practice/technology was not as effective or efficient as we had originally hoped it would be. (R)	89.19
	Using the new practice/technology, we achieved greater productivities than we originally planned.	97.30
	Compared to our original expectations, the new practice/technology achieved significantly better overall technical improvements.	97.30
on-time performance	The implementation actually took significantly more time than originally planned. (R)	100.00

Table A2 (continued)

Construct	Questionnaire item	% Correctly sorted
Implementation radicalness	In order to use the new practice/technology, the operators/users had to learn new skills and procedures.	75.68
	Much training was required for operators/users in order to use the new practice/technology.	78.38
	The implementation of this practice/technology required significant changes in our assets such as tools and equipment.	91.89
Provenness of technology	This practice/technology had been implemented successfully in other organizations before we adopted it.	56.76
	Irregularities and problems with this technology/practice had been resolved before we adopted it.	78.38
	Before we started the implementation process, there were known unresolved problems with the practice/technology itself. (R)	75.68
	Before we implemented this technology/practice, its effectiveness had been demonstrated by successful adoptions in many other organizations.	72.97
Project selection rigor	Before choosing the practice/technology, we compared the resources that were required (e.g., tools and equipment and operators' skills) and what we had.	54.05
	Before choosing this practice/technology, we followed rigorous technology selection guideline.	78.38
	In choosing this technology, we used detailed information on the existing user environment, product and production system.	54.05
	In choosing this practice/technology, we used information from past experiences in implementing new manufacturing processes.	27.03
	Before choosing this practice/technology, we did an initial feasibility study.	75.68
Project team technical competence	Implementation team members were highly skilled.	86.49
	Each individual on the implementation team had useful experience.	67.57
	implementation team members were experts in their particular jobs and functions.	56.76
	implementation team members were considered among the best people in the organization.	91.89
Project team diversity	Many functional areas were represented on the implementation team.	86.49
	The implementation team included people from different functional groups.	94.59
	The implementation team included people from diverse functional areas.	94.59

Appendix 2 Survey Questionnaire

MSU Manufacturing Process Implementation Study

At any point in the survey, you can go back to change your previous responses by clicking "Previous Page". All responses are submitted to us only when you click "Submit Survey" on the last page of the survey.

If you have to leave this page at any point, as long as you use the same computer, when you access the survey again you can go back directly to the part where you have left off.

---

1) Please enter the pass code contained in the invitation letter or e-mail. If you do not have a pass code, please enter "Guest".

2) Please fill in your name and e-mail address below, so that we can send you an electronic summary of the best practices uncovered by this research. (We also need this information to remove you from future invitation mailings.)

Name:

E-mail:

3) Please select the charity that you would like us to donate $5 to.

- Habitat for humanity
- National Childhood Cancer Foundation
- Red cross
- UNICEF

4) Have you been directly involved in a manufacturing process implementation project (e.g., implementing new routines/procedures and tools, equipment or machinery) that was completed in the last 3-9 months, and are you willing to participate in this survey?

- Yes --- Please skip to question 7.
- No --- Please answer questions 5 and 6, and click "Next Page" to

submit this information and close the survey.

5) Could you refer us to someone in your organization who may have been involved in a manufacturing process implementation project that was completed in the last 3-9 months?

Name:

E-mail:

Name:

E-mail:

6) May we know the reason you are choosing not to participate?

- I have not been involved in implementing any new manufacturing process.
- I have not been involved in implementing any new manufacturing process that was completed in the last 3-9 months.
- I do not have time to complete the survey.
- Other (please specify)

If you selected other, please specify:

7) Which of the following titles best describes your position in the organization? (Please select all that apply.)

- Upper Management
- Middle Management
- First Level Management
- Engineer or Other Trained Professional
- Consultant/Contract Employee
- Researcher
- Other (please specify)

If you selected other, please specify:

8) Which of the following best describes the functional area in which you work?

- Marketing/Sales
- Development/Engineering
- MIS/Information Technology
- Finance/Accounting
- Manufacturing/Operations/Maintenance
- Personnel/Human resources
- Other (please specify)

If you selected other, please specify:

9) What is the name of your company?

10) Approximately how many people are employed globally in your company?

- Between 100-500 people
- Between 501-1,000 people
- Between 1,001-5,000 people
- More than 5,000 people

11) Think about all of the manufacturing process innovations and improvements your company has implemented over the past 5 years. What percentage of these innovations was: (Answers must add up to 100%)

designed/invented mostly by parties outside your firm? (%)

designed/invented mostly by internal R&D? (%)

designed/invented mostly as a collaboration between external and internal parties? (%)

12) Over the past 5 years, approximately what percentage of manufacturing process innovation projects undertaken by your company was: (Answers muct add up to 100%)

incremental changes which build upon existing practice/technology? (%)

completely new to the firm and replacing existing practice/technology? (%)

---

13) The rest of the questions in this survey will ask you about the most recent manufacturing process innovation that you were directly involved with.
Please keep the following definitions in mind. Manufacturing process innovation refers to all activities required to invent and implement a new manufacturing process. Our definition of a new manufacturing process innovation includes everything from a minor change such as a change in procedures to a major change such as installation of new equipment.
Design/Invention phase refers to the design process in which requirements (e.g., technology, particular skills and materials) and technical specifications (e.g., processing speed, quality) of a new manufacturing practice or technology are determined. This may occur somewhere else outside your organization. We will refer to an invention outcome as a new "practice/technology".
Implementation Phase is the process in which the new practice/technology is modified and installed. This could include making changes to the user organization as well as the practice/technology itself.
Please check below to indicate that you have read and understand the above definitions and instruction.

- I understand the above definitions and instruction.

14) In 1-2 sentences please briefly describe the last manufacturing practice/technology implementation project completed between 3-9 months, in which you were directly involved.

15) How long ago was this project completed (weeks)?

16) Which of the following types of operations best describes the process that was affected by the implementation of the new practice/technology you referred to?

- Job shop (Production of small volumes of a large number of different products)

Batch (Production of large volumes of similar items on a repeat basis)

Assembly line (Production of discrete parts moving from workstation to workstation at a controlled rate)

Continuous flow (Processing of undifferentiated materials such as petroleum or chemicals)

17) What were the primary reasons the new manufacturing practice/technology was implemented? (Check all that apply)

- A new product launch
- A product modification
- Kaizen/continuous improvement event
- Parent corporation's requirement
- Customer's demand
- Vendor's suggestion
- Other (please specify)

If you selected other, please specify:

18) How many people are employed at the manufacturing plant where the practice/technology was implemented?

19) What was the scope of operations affected by this implementation?

- A single work center
- A production line
- A department
- The entire plant
- Multiple plants

20) Compared to what was originally planned:

Significantly	Slightly	As	Slightly	Significantly

	more than originally planned ---1---	more than originally planned ---2---	originally planned ---3---	less than originally planned ---4---	less than originally planned ---5---
How much man power was actually used in the planning, testing and installation of the new practice/technology?					
How much capital expenditure was actually used in the implementation?					
How much time did the implementation actually take?					

21) Please rate the extent to which you agree or disagree with the following statements regarding achievement of technical targets.

	Strongly Disagree ---1---	Disagree ---2---	Neutral --3--	Agree --4--	Strongly Agree ---5---	Not Applicable
Using the new practice/technology, we achieved greater productivities than we originally planned.						
The new practice/technology improved the quality of our process more than we had originally expected it would.						
The new practice/technology improved our responsiveness more than we had hoped.						
The new practice/technology						

achieved significantly better overall technical improvements than we had originally expected it would.						
The new practice/technology performed significantly better than we had originally expected it would.	○	○	○	○	○	○
The new practice/technology was not as effective or efficient as we had originally hoped it would be.	○	○	○	○	○	○

22) To what extent was the original budget/projected cost of the implementation project met?

- ○ Actual cost was significantly more than the original budget.
- ○ Actual cost was slightly more than the original budget.
- ○ Actual cost was as originally budgeted.
- ○ Actual cost was slightly less than the original budget.
- ○ Actual cost was significantly less than the original budget.

23) Relative to other similar implementation projects undertaken in this company, this project took:

- ○ Significantly less time
- ○ Slightly less time
- ○ Same amount of time
- ○ Slightly more time
- ○ Significantly more time
- ○ We have not undertaken any similar implementation projects.

24) How satisfied were top managers with how fast the implementation project took place?

- Very satisfied
- Somewhat satisfied
- Neither satisfied nor dissatisfied
- Somewhat dissatisfied
- Very dissatisfied

25) In evaluating the performance of this implementation project, what percentage weight (or importance) was given to each criterion of success? (Answers must add up to 100%)

Technical goals achievement ____

Budget attainment ____

Schedule adherence ____

26) Please give us your estimate of the percentage return on investment (ROI) and the payback period of the implementation project?

ROI (%): ____

Payback (years): ____

27) Is the implemented practice/technology still being used?

- Yes
- No (please specify why in the comments field)

Additional comments:

____

28) At its end, to what degree (%) was the implementation project over- or under-budget? ((Actual cost/ budget cost -1)*100)

Percent below initial budget (%): ____

Percent above initial budget (%): ____

29) How long (weeks) was the implementation project initially intended to take?

____

30) How long (weeks) did it actually take?

31) Questions on this page will ask you about the design of the adopted manufacturing practice/technology, how it was selected and where its design/invention took place.
As a reminder, the design/invention phase refers to the design process in which requirements (e.g., technology, particular skills and materials) and technical specifications (e.g., processing speed, quality) of a new manufacturing practice or technology are determined. This may occur somewhere else outside your organization. We will refer to an invention outcome as a new "practice/technology".
Please rate the extent to which you agree or disagree with the following statements regarding the design/invention of the practice/technology that was adopted.

	Strongly Disagree ---1---	Disagree ---2---	Neutral --3--	Agree --4--	Strongly Agree ---5---
The design of this practice/technology was new to the world.					
The new practice/technology was simply a minor modification of industry best practice/ technology.					
The new practice/technology made existing industry best practice/technology obsolete.					

32) Please rate the extent to which you agree or disagree with the following statements regarding the provenness of the new practice/technology:

	Strongly Disagree ---1---	Disagree ---2---	Neutral --3--	Agree --4--	Strongly Agree ---5---
Before we implemented this practice/technology, its effectiveness had been demonstrated by successful adoptions in many other organizations.					
Before we started the implementation process, there were known unresolved problems with the practice/technology itself.					

This practice/technology had been implemented successfully in other organizations before we adopted it.	◌	◌	◌	◌	◌
Irregularities of this practice/technology had been resolved before we adopted it.	◌	◌	◌	◌	◌

33) Please rate the extent to which you agree or disagree with the following statements regarding the selection of the adopted practice/technology:

	Strongly Disagree ---1---	Disagree ---2---	Neutral --3--	Agree --4--	Strongly Agree ---5---
Before choosing this practice/technology, we compared the resources that were required (e.g., tools, equipment, operators' skills) to what we had.	◌	◌	◌	◌	◌
Before choosing this practice/technology, we did a thorough feasibility study.	◌	◌	◌	◌	◌
Before choosing this practice/technology, we followed rigorous technology selection guidelines.	◌	◌	◌	◌	◌
In choosing this practice/ technology, we used detailed information on the existing user environment, product and production system.	◌	◌	◌	◌	◌
In choosing this practice/technology, we used information from past experiences in implementing new manufacturing processes.	◌	◌	◌	◌	◌

34) Please rate the extent to which you agree or disagree with the following statements regarding the changes required in this implementation project:

	Strongly Disagree ---1---	Disagree ---2---	Neutral --3--	Agree --4--	Strongly Agree ---5---
The implementation of this practice/technology required significant changes in the our assets such as tools and equipment.					
In order to use the new practice/technology, the operators/users had to learn new skills and procedures.					
Much training was required for operators/users in order to use the new practice/technology.					

35) What percentage of the design/invention of the new manufacturing practice/technology you described was done by: (Answers must add up to 100%)

a.) Personnel (managers, engineers and workers) at the implementation site? (%)

b.) Corporate support functions (engineers and others not located at the site)? (%)

c.) External sources (vendors, suppliers, university labs, etc.)? (%)

36) If your answer to 35 c.) is more than zero, please answer this question. Otherwise, please proceed to the next question.

Think of the most important external sources of the design/invention. For up to 3 of these, please approximate the percentage of the design that each contributed. If there were less than 3, leave the extra fields below blank. (The sum of these contributions cannot exceed your answer for 35 c.)

What percentage of the total design/invention did External source 1 contribute? (%)

What percentage of the total design/invention did External source

2 contribute? (%)

What percentage of the total design/invention did External source 3 contribute? (%)

37) If corporate support functions or external sources were involved in the design/invention, please answer this and the next question. Otherwise, please skip to question 39.

Please indicate the item that best describes the working relationship that personnel at the implementation site had with the following sources.

	Extremely close ---1---	Very close -2-	Somewhat close ---3---	Not very close --4--	Not close at all --5--
Relationship with contributing corporate support functions					
Relationship with external source 1					
Relationship with external source 2					
Relationship with external source 3					

38) How many miles away was each design/invention source from the implementation site? (Enter NA if not applicable.)

Contributing corporate support functions (miles):

External source 1 (miles):

External source 2 (miles):

External source 3 (miles):

39) Approximately how many years before implementation did each source make their contribution to the design/invention? (Enter NA if not applicable.)

Personnel at the implementation site (years):

Corporate support functions (years):

External source 1 (years):

External source 2 (years):

External source 3 (years):

40) Questions on this page will ask you about the implementation team members of the manufacturing process innovation which you referred to in the previous page of the survey.
As a reminder, the implementation phase is the process in which the pratice/technology is modified and installed. This could include making changes to the user organization as well as the practice or technology itself.
Which of the following titles best describe(s) your role on the implementation project? (Select all that apply.)

- Project manager
- Functional manager
- Project team member
- Project sponsor/champion
- Other (please specify)

If you selected other, please specify:

41) Approximately what percentage of the personnel on the implementation team: (Answers must add up to 100%)

had a high school degree? (%)

had a 2-year associate degree? (%)

had an undergraduate degree? (%)

had a graduate degree? (%)

42) Approximately what percentage of the personnel on the implementation team: (Answers must add up to 100%)

had less than 5 years of work experience? (%)

had between 5-15 years of work experience? (%)

had more than 15 years of work experience? (%)

43) Please rate the extent to which you agree or disagree with the following statements regarding implementation team members.

	Strongly Disagree ---1---	Disagree ---2---	Neutral --3--	Agree --4--	Strongly Agree ---5---
Implementation team members were highly skilled					
The implementation team included people from diverse functional areas.					
Implementation team members were considered among the best people in the organization.					
Many functional areas were represented on the implementation team					
Implementation team members were experts in their particular jobs and functions.					
Each individual on the implementation team had useful experience.					
The implementation team included people from different functional groups.					

44) What percentage of the personnel on the implementation team was from the following functional area? (Answers must add up to 100%)

Manufacturing engineering (%):

Product design engineering (%):

Quality control (%):

Production control (%):

Maintenance (%):

Production/Manufacturing (%):

Purchasing (%):

Management information system (%):

Others (%):

45) What percentage of the personnel on the implementation team worked at the implementation site before the implementation project began? (%)

46) Please rate the extent to which you agree or disagree with the following statements which describe the implementation team.

	Strongly Disagree ---1---	Disagree ---2---	Neutral --3--	Agree --4--	Strongly Agree ---5---
If an implementation team member made a mistake on this team, it was held against him/her.					
Team members feared that bringing up problem/issues would have negative effects on their career prospects.					
People on this team sometimes rejected other members.					
It was safe to take a risk on this team.					
No one on this team would deliberately act in a way that undermined my efforts.					
Each member of the implementation team felt they were valuable to the team.					

47) Please rate the extent to which you agree or disagree with the following statements describing how the implementation team felt about the project goals at the beginning of the implementation project:

	Strongly Disagree ---1---	Disagree ---2---	Neutral --3--	Agree --4--	Strongly Agree ---5---
At the start of the project, we felt the original project budget was overly optimistic.	○	○	○	○	○
At the start of the project, we felt the original project schedule was overly optimistic .	○	○	○	○	○
At the start of the project, we felt the original project technical goals were overly optimistic.	○	○	○	○	○
At the start of the project, we were confident that we could achieve the project budget.	○	○	○	○	○
At the start of the project, we were confident that we could achieve the project schedule.	○	○	○	○	○
At the start of the project, we were confident that we could achieve the project's technical goals.	○	○	○	○	○

48) Please rate the extent to which you agree or disagree with the following statements about communication among the implementation team members:

	Strongly	Disagree	Neutral	Agree	Strongly

	Disagree ---1---	---2---	--3--	--4--	Agree ---5---
Implementation team members talked openly and freely.	○	○	○	○	○
Implementation team members did not seem to understand what one another was saying during their discussions.	○	○	○	○	○
When implementation team members shared information it was likely to be used.	○	○	○	○	○
Team members shared information in useful formats.	○	○	○	○	○
Team members often shared valuable information.	○	○	○	○	○

49) At the point in the implementation project when the number of staff was at its peak, approximately how many persons were:

Assigned full-time to the implementation project? [ ]

Assigned on a part-time basis only to the implementation project? [ ]

50) Can you refer us to other members of the implementation team that may be able to answer questions in this survey?

Name: [ ]

E-mail: [ ]

Name: [ ]

E-mail: [ ]

BIBLIOGRAPHY

Abernathy, W. J. and M. Utterback (1978). "Patterns of technological innovation." Technology Review 80(June-July): 40-47.

Albino, V., N. Carbonara and I. Giannoccaro (2006). "Innovation in industrial districts: An agent-based simulation model." International Journal of Production Economics 104(1): 30.

Ancona, D. G. and D. F. Caldwell (1992). "Demography and design: predictors of new product team performance." Organization Science 3(3): 321-341.

Anderson, N., C. K. W. D. Dreu and B. A. Nijstad (2004). "The routinization of innovation research: a constructively critical review of the state-of-the-science." Journal of Organizational Behavior 25(2): 147.

Argote, L., B. McEvily and R. Reagans (2003). "Managing knowledge in organizations: an integrative framework and review of emerging themes." Management Science 49(4): 571.

Argyris, C. and D. Schon (1978). Organizational learning: a theory of action perspective. Reading, MA, Addison-Wesley.

Baer, M. and M. Frese (2003). "Innovation is not enough: Climates for initiative and psychological safety, process innovations, and firm performance." Journal of Organizational Behavior 24(1): 45.

Bagozzi, R. P. and Y. Yi (1991). "Multitrait-multimethod matrices in consumer research." Journal of Consumer Research 17: 426-439.

Bagozzi, R. P., Y. Yi and L. W. Philips (1991). "Assessing construct validity in organizational research." Administrative Science Quarterly 36(3): 421-458.

Baines, T., D. E. Whitney and C. Fine (1999). "Manufacturing technology sourcing practices in the USA." International Journal of Production Research 37(4): 939-956.

Bamberger, P. (1991). Reinventing innovation theory: critical issues in the conceptualization, measure,ent, and analysis of technological innovation. Research in the sociology of organizations. S. B. Bacharach. Greenwich, CT, Jai Press Inc.

Barney, J. (1991). "Firm resources and sustained competitive advantage." Journal of Management 17(January): 99-120.

Baron, R. M. and D. A. Kenny (1986). "The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations." Journal of personality and social psychology 51(6): 1173-1182.

Beatty, C. A. (1992). "Implementing advanced manufacturing technologies: rules of the road." Sloan Management Review 33(4): 49-60.

Belassi, W. and O. I. Tukel (1996). "A new framework for determining critical success/failure factors in projects." International Journal of Project Management 14(3): 141-151.

Boyer, K. K. and R. Verma (2000). "Multiple raters in survey-based operations management research: a review and tutorial." Production and Operations Management 9(2): 128-140.

Bradshaw, G. F., P. W. Langley and H. A. Simon (1983). "Studying scientific discovery by simulation." Science 222: 971-975.

Burcher, P., G. Lee and A. Sohal (1999). "Lessons for implementing AMT Some case experiences with CNC in Australia, Britain and Canada." International Journal of Operations & Production Management 19(5/6): 515.

Choudhury, M. A., T. Azid and M. A. Klasra (2006). "Knowledge-induced technological change:A study involving the automobile innovation in Malaysia with layers of techniques." International Journal of Social Economics 33(11): 744-765.

Co, H. C., B. E. Patuwo and M. Y. Hu (1998). "The human factor in adanced manufacturing technology adoption." International Journal of Operations & Production Management 18(1): 87-106.

Cohen, M. A., J. Eliashberg and T.-H. Ho (1996). "New product development: The performance and time-to-market tradeoff." Management Science 42(2): 173.

Cohen, W. M. and D. A. Levinthal (1990). "Absorptive Capacity: A New Perspective On Learning And Innovation." Administrative Science Quarterly 35(1): 128.

Cote, J. A. and M. R. Buckley (1987). "Estimating trait, method, and error variance: Generalizing across 70 construct validation studies." Journal of marketing research 24(3): 315-318.

Cummings, J. C. (2004). "Work groups, structural diversity and knowledge sharing in a global organization." Management Science 50(3): 352-364.

Damanpour, F. (1996). "Organizational complexity and innovation: developing and testing multiple contingency models." Management Science 42(5): 693.

Damanpour, F. and S. Gopalakrishnan (2001). "The dynamics of the adoption of product and process innovations in organizations." Journal of Management Studies 38(1): 2001.

Davenport, T. H. (1993). Process innovation: rengineering work through unformation technology. Boston, MA, Harvard Business School Press.

Davies, A. J. and A. K. Kochhar (2000). "A framework for the selection of best practices." International Journal of Operations & Production Management 20(10): 1203.

Detert, J. R. and R. G. Schroeder (2000). "A framework for linking culture and improvement initiatives in organizations." Academy of Management Review 25(4): 850.

Drake, A., S. F. Haka and S. P. Ravenscroft (2001). "An ABC simulation focusing on incentives and innovation." Issues in Accounting Education 16(3): 443.

Drake, A. R., S. F. Haka and S. P. Ravenscroft (1999). "Cost system and incentive structure effects on innovation, efficiency and profitability in teams." The Accounting Review 74(3): 323.

Dutta, S., O. Narasimhan and S. Rajiv (1999). "Success in High-Technology Markets: Is Marketing Capability Critical?" Marketing Science 18(4): 547.

Earley, P. C. and E. Mosakowski (2000). "Creating hybrid team cultures: an empirical test of transnational team functioning." Academy of Management Journal 43(1): 26-49.

Edmondson, A. C. (1999). "Psychological safety and learning behavior in work teams." Administrative Science Quarterly 44: 350-383.

Edmondson, A. C. (2003). "Framing for learning: lessons in successful technology implementation." California Management Review 45(2): 34.

Edmondson, A. C., R. M. Bohmer and G. P. Pisano (2001). "Disrupted routines: team learning and new technology implementation in hospitals." Administrative Science Quarterly 46: 685-716.

Edmondson, A. C., A. B. Winslow, R. M. Bohmer and G. P. Pisano (2003). "Learning how and learning what: effects of tacit and codified knowledge on performance improvement following technology adoption." Decision Sciences 34(2): 197.

Eisenhardt, K. M. and J. Martin (2000). "Dynamic Capabilities: What are they?" Strategic Management Journal 21: 1105-1121.

Engardio, P. (2006). R&D offshoring: Is it working?, Business Week Online.

Ettlie, J. E. and S. A. Reifeis (1987). "Integrating Design and Manufacturing to Deploy Advanced Manufacturing Technology." Interfaces 17(6): 63.

Ettlie, J. E. and E. M. Reza (1992). "Organizational Integration and Process Innovation." Academy of Management Journal 35(4): 795.

Fedor, D. B., S. Ghosh, S. D. Cladwell, T. J. Maurer and V. R. Singhal (2003). "The effects of knowledge management on team members' ratings of project success and impact." Decision Sciences 34(3): 513.

Flynn, B. B., S. Sakakibara and R. G. Schroeder (1995). "Relationship between JIT and TQM: Practices and performance." Academy of Management Journal 38(5): 1325.

Fornell, C. and D. F. Larcker (1981). "Evaluating structural equation models with unobservable variables and measurement." Journal of marketing research 18: 39-50.

Frohlich, M. T. and J. R. Dixon (1999). "Information systems adaptation and the successful implementation of advanced manufacturing technologies." Decision Sciences 30(4): 921-957.

Gooding, R. Z. and J. A. Wagner III (1985). "A meta-analytic review of the relationship between size and performance: the productivity and efficiency of organizations and their subunits." Administrative Science Quarterly 30: 462-481.

Govindarajan, V. and P. K. Kopalle (2006). "Disruptiveness of innovations: measurement and an assessment of reliability and validity." Strategic Management Journal 27: 189-199.

Granello, D. H. and J. E. Wheaton (2004). "Online data collection: strategies for research." Journal of counseling & development 82: 387-393.

Ha, A. Y. and E. L. Porteus (1995). "Optimal timing of reviews in concurrent design for manufacturability." Management Science 41(9): 1431.

Hayes, R. H. and S. C. Wheelwright (1984). Restoring our competitive edge: competing through manufacturing, John Wiley & Sons, Inc.

Hewitt, F. (1995). "Business process innovation in the mid-1990s." Integrated manufacturing systems 6(2): 18.

Hoegl, M. and Gemuenden (2001). "Teamwork quality and the success of innovative projects: a theoretical concept and empirical evidence." Organization Science 12(4): 435.

Hoegl, M. and L. Proserpio (2004). "Team member proximity and teamwork innovative projects." Research Policy 33: 1153-1165.

Holahan, P. J., Z. H. Aronson, M. P. Jurkat and F. D. Schoorman (2004). "Implementing computer technology: a multiorganizational test of Klein and Sorra's model." Journal of Engineering and Technology Management 21: 31-50.

Hottenstein, M. P. and J. W. Dean Jr. (1992). "Managing risk in advanced manufacturing technology." California Management Review 34(4): 112.

Hu, L. and P. M. Bentler (1995). Evaluating model fit. Structural equation modeling: concepts, issues and applications. R. H. Hoyle. Thousand Oaks, CA, Sage Publications.

Hu, L. and P. M. Bentler (1998). "Fit indices in covariance structure modeling: sensitivity to underparameterized model misspecification." Psychological Methods 3(4): 424-453.

Hu, L. and P. M. Bentler (1999). "Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives." Psychological Methods 6(1): 1-55.

Iansiti, M. (2000). "How the incumbent can win: Managing technological transitions in the semiconductor industry." Management Science 46(2): 169.

James, L. R., R. G. Demaree and G. Wolf (1984). "Estimating within-group interrater reliability with and without response bias." Journal of Applied psychology 69: 85-98.

Jayanthi, S. and K. K. Sinha (1998). "Innovation implementation in high technology manufacturing: A chaos-theoretic empirical analysis." Journal of Operations Management 16: 471-494.

Jugdev, K. (2004). "Through the looking glass: examining theory development in project management." Project Management Journal 35(3): 15.

Katz, R. and T. J. Allen (1988). Investigating not invented here (NIH) syndrome: a look at the performance, tenure, and communication patterns of 50 R&D project groups. Readings in the management of innovation. W. L. Moore. New York, NY, Ballinger/Harper & Row: 293-309.

Kazanjian, R. K. and R. Drazin (1986). "Implementing Manufacturing Innovations: Critical Choices of Structure and Staffing Roles." Human Resource Management 25(3): 385-403.

Kerzner, H. (1987). "In search of excellence in project management." Journal of Systems Management 38(2): 30.

Khurana, A. (1999). "Managing complex production processes." Sloan Management Review Winter.

Kimzey, C. H. and S. Kurokawa (2002). "Technology outsourcing in the U.S. and Japan." Research Technology Management 45(4): 36.

Klein, K. J., A. b. Conn and J. S. Sorra (2001). "Implementing computerized technology: an organizational analysis." Journal of Applied psychology 86(5): 811-824.

Klein, K. J. and A. P. Knight (2005). "Innovation implementation: overcoming the challenge." American Psychology Society 14(5): 243.

Klein, K. J. and J. S. Sorra (1996). "The challenge of innovation implementation." Academy of Management Review 21: 1055-1080.

Leonard-Barton, D. (1988). "Implementation as mutual adaptation of technology and organization." Research Policy 17: 251-267.

Lewin, A. Y. and C. Peeters (2006). "The top-line allure of offshoring." Harvard Business Review 84(3): 22.

Linderman, K., R. G. Schroeder and A. S. Choo (2006). "Six sigma: the role of goals in improvement teams." Journal of Operations Management 24(6): 779-790.

Linderman, K., R. G. Schroeder and A. S. Choo (In-press). "Six sigma: the role of goals in improvement teams." Journal of Operations Management.

Macher, J. T. and D. C. Mowery (2003). ""Managing" learning by doing: An empirical study in semiconductor manufacturing." The Journal of Product Innovation Management 20(5): 391.

Malhotra, N. K., S. S. Kim and A. Patil (2006). "Common method variance in IS research: a comparison of alternative approaches and a reanalysis of past research." Management Science 52(12): 1865-1883.

Mangione, T. W. (1998). Mail Surveys. Handbook of Applied Social Research Methods. D. J. Rog. Thousand Oaks, CA, SAGE Publications Ltd.: 399-427.

McDermott, C. M. and G. N. Stock (1999). "Organizational culture and advanced manufacturing technology implementation." Journal of Operations Management 17(5): 521.

McLachlin, R. (2004). "Internal plant environment and just-in-time manufacturing." International Journal of Manufacturing Technology and Management 6(2): 112-124.

Menon, T. and J. Pfeffer (2003). "Valuing internal vs. external knowledge: explaining the preference for outsiders." Management Science 49(4): 497.

Menon, T., L. Thompson and H.-S. Choi (2006). "Tainted knowledge v. tempting knowledge: people avoid knowledge from internal rivals and seek knowledge from external rivals." Management Science 52(8): 1129-1144.

Meyers, P. W., K. Sivakumar and C. Nakata (1999). "Implementation of industrial process innovations: factors, effects and marketing implications." Journal of Product Innovation Management 16: 295-311.

Moenaert, R. K. and W. E. Souder (1996). "Context and antecedents of information utility at the R&D/Marketing interface." Management Science 42(11): 1592.

Moore, G. C. and I. Benbasat (1991). "Development of an instrument to measure the perceptions of adopting an information technology innovation." Information systems research 2(2): 192-222.

Nahm, A. Y., S. S. Rao, L. Solis-Galvan and T. S. Ragu-Nathan (2002). "The Q-sort method: assessing reliability and construct validity of questionnaire items at a pre-testing stage." Journal of modern applied statistical methods 1(1): 114-125.

Neter, J., M. H. Kutner, C. J. Nachtsheim and W. Wasserman (1996). Applied linear regression models, McGraw -Hill Irwin.

Nonaka, I. (1991). "The Knowledge-Creating Company." Harvard Business Review 69(6): 96.

Nunnally, J. C. (1967). Psychometric Theory. New York, McGraw-Hill.

O'Leary-Kelly, S. W. and R. J. Vokurka (1998). "The empirical assessment of construct validity." Journal of Operations Management 16: 387-405.

Pfeffer, J. and C. A. O'Reilly (1987). "Hospital demography and turnover among nurses." Industrial Relations 36: 158-173.

Pilkington, A. (1998). "Manufacturing strategy regained: evidence for the demise of best-practice." California Management Review 41(1): 31.

Pinto, J. K. and S. J. J. Mantel (1990). "The causes of project failure." IEEE Transactions on Engineering Management 37(4).

Pinto, M. B., J. K. Pinto and J. E. Prescott (1993). "Antecedents and consequences of project team cross-functional cooperation." Management Science 39(10): 1281.

Pisano, G. (1997). The Development Factory: Unlocking The Potential of Process Innovation. Boston, MA, Harvard Business School Press.

Podsakoff, P. M., S. B. MacKenzie, J.-Y. Lee and N. P. Podsakoff (2003). "Common method biases in behavioral research: A critical review of the literature and recommended remedies." Journal of Applied psychology 88(5): 879-903.

Prahalad, C. K. and G. Hamel (1995). "The Core Competence of the Corporation." Harvard Business Review(July-August): 118-128.

Primo, M. A. M. and S. D. Amundson (2002). "An exploratory study of the effects of supplier relationships on new product development outcomes." Journal of Operations Management 20: 33-52.

Quinn, R. E. and J. Roghbaugh (1981). "A competing values approach to organizational effectiveness." Public productivity review 5: 122-140.

Repenning, N. P. (2002). "A simulation-based approach to understanding the dynamics of innovation implementation." Organization Science 13(2): 109-127.

Repenning, N. P. and J. D. Sterman (2002). "Capability traps and self-confirming attribution errors in the dynamics of process improvement." Administrative Science Quarterly 47: 265-295.

Salaheldin, S. I. (2005). "JIT implementation in Egyptian manufacturing firms: some empirical evidence." International Journal of Operations & Production Management 25(3): 354-369.

Sarin, S. and C. M. McDermott (2003). "The effect of team leader characteristics on learning, knowledge application, and performance of cross-functional new product development teams." Decision Sciences 34(4): 707-739.

Schroeder, R. G., G. D. Scudder and D. R. Elm (1989). "Innovation in Manufacturing." Journal of Operations Management 8(1): 1.

Sedgley, N. and B. Elmslie (2001). "Agglomeration and congestion in the economics of ideas and technological change." The American Journal of Economics and Sociology 60(1): 101-121.

Sen, F. and A. H. Rubenstein (1989). "External technology and in-house R&D's facilitative role." Journal of Product Innovation Management 6: 123-138.

Sen, F. and A. H. Rubenstein (1990). "An exploration of factors affecting the integration of in-house R&D with external technology acquisitioni strategies of a firm." IEEE Transactions on Engineering Management 37(4): 246.

Shani, A. B., R. M. Grant, R. Krishnan and E. Thompson (1992). "Advanced manufacturing systems and organizational choice: sociotechnical system approach." California Management Review 34(4): 91.

Sharma, R. and P. Yetton (2004). "The contingent effects of management support and task interdependence on successful information systems implementation." MIS Quarterly 27(4): 533-555.

Sharma, S., R. M. Durand and O. Gur-Arie (1981). "Identification and analysis of moderator variables." Journal of marketing research 18(3): 291-300.

Shenhar, A. J. (2001). "One Size Does Not Fit All Projects: Exploring Classical Contingency Domains." Management Science 47(3): 394-414.

Shenhar, A. J., A. Tishler, D. L. Dvir and T. Lechler (2002). "Refining the search for project success factors: a multivariate, typological approach." R&D Management 32(2): 111-126.

Sila, I. (2007). "Examining the effects of contextual factors on TQM and performance through the lens of organizational theories: an empirical study." Journal of Operations Management 25: 83-109.

Simon, H. A. (1985). What we know about the creative process. Frontiers in creative and innovation management. R. L. Kuhn. Cambridge, MA, Ballinger: 3-20.

Sinha, U. B. (2006). "Patent Enforcement, Innovation and Welfare." Journal of Economics 88(3): 211-241.

Skinner, W. (1969). "Manufacturing-missing link in corporate strategy." Harvard Business Review 47(May-June): 136-145.

Small, M. H. and M. M. Yasin (1997). "Advanced manufacturing technology: Implementation policy and performance." Journal of Operations Management 15(4): 349.

Smith, K. G., C. J. Collins and K. D. Clark (2005). "Existing knowledge, knowledge creation capability and the rate of new product introduction in high-technology firms." Academy of Management Journal 48(2): 346-387.

Spear, S. and H. K. Bowen (1999). "Decoding the DNA of the Toyota Production System." Harvard Business Review 77(5): 96.

Starbuck, W. H. and J. M. Mezias (1996). "Opening Pandora's box: Studying the accuracy of managers' perceptions." Journal of Organizational Behavior 17(2): 99.

Stewart, G. (2006). "A meta-analytic review of relationships between team design features and team performance." Journal of Management 32(1): 29-54.

Stock, G. N. and M. V. Tatikonda (2004). "External technology integration in product and process development." International Journal of Operations & Production Management 24(7): 642.

Stratman, J. K. and A. V. Roth (2002). "Enterprise Resource Planning (ERP) Competence Constructs: Two-Stage Multi-Item Scale Development and Validation." Decision Sciences 33(4): 601-628.

Subramaniam, M. and M. A. Youndt (2005). "The influence of intellectual capital on the types of innovative capabilities." Academy of Management Journal 48(3): 450-463.

Sundbo, J. (1999). The Theory of Innovation: Entrepreneurs, Technology and Strategy. Cheltenham, UK, Edward Elgar Publishing Limited.

Swink, M. (2000). "Technological innovativeness as a moderator of new product design integration and top management support." The Journal of Product Innovation Management 17(3): 208.

Swink, M. (2002). "Product development--faster, on-time." Research Technology Management 45(4): 50.

Teece, D., G. Pisano and A. Shuen (1997). "Dynamic Capabilities and Strategic Management." Strategic Management Journal 18(7): 509-533.

Troy, L. (2006). Almanac of business and industrial financial ratios, CCH, Wolters Kluwer.

Tu, Q., M. A. Vonderembse, T. S. Ragu-Nathan and T. W. Sharkey (2006). "Absorptive capacity: enhancing the assimilation of time-based manufacturing practices." Journal of Operations Management 24: 692-710.

Turner, J. R. (2004). "Five necessary conditions for project success." International Journal of Project Management 22: 349.

Tyre, M. J. and O. Hauptman (1992). "Effectiveness of organizational responses to technological change in the production process." Organization Science 3(3): 301-320.

Tyre, M. J. and W. J. Orlikowski (1993). "Exploiting opportunities for technological improvement in organizations." Sloan Management Review 35(1): 13.

Tyre, M. J. and W. J. Orlikowski (1994). "Windows of opportunity: temporal patterns of technological adaptation in organizations." Organization Science 5(1): 98.

Vanhaverbeke, W., G. Duysters and N. BNoorderhaven (2002). "External technology sourcing through alliances or acquisitions: an analysis of the application-specific integrated circuits industry`." Organization Science 13(6): 714.

Wagner III, J. A. and J. R. Hollenbeck (1992). Management of Organizational Behavior. Englewood Cliffs, NJ, Prentice-Hall.

Waterson, P. E., C. W. Clegg, R. Bolden, K. Pepper, P. B. Warr and T. D. Wall (1999). "The use and effectiveness of modern manufacturing practices: a survey of UK industry." International Journal of Production Research 37: 2271-2292.

Werts, C. E., R. L. Linn and K. G. Joreskog (1974). "Interclass reliability estimates: testing structural assumptions." Educational and psychological measurement 34: 25-33.

West, S. G., J. F. Finch and P. J. Curran (1995). Structural equations models with nonnormal variables: problems and remedies. Structural equation modeling: concepts, issues and applications. R. H. Hoyle. Thousand Oaks, CA, Sage Publications.

Zahra, S. A. and S. R. Das (1993). "Innovation Strategy and Financial Performance in Manufacturing Companies: An Empirical Study." Production and Operations Management 2(1): 15.

Zahra, S. A. and G. George (2002). "Absorptive capacity: A review, reconceptualization, and extension." Academy of Management. The Academy of Management Review 27(2): 185.

Zammuto, R. F. and E. J. O'Connor (1992). "Gaining advanced manufacturing technologies' benefits: the roles of organization design and culture." Academy of Management Review 17(4): 701-728.

Zollo, M. and S. G. Winter (2002). "Deliberate learning and the evolution of dynamic capabilities." Organization Science 13(3): 339.