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Graduate School

PROCESS IMPROVEMENT PROGRAM MANAGEMENT AND PERFORMANCE:
The Mediating Role of Strategic Project Selection

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DEDICATION

To my wife Zhangyi Shi
Who loves and supports me all the time…

My parents Mixin Chen and Bohuan Zhang
Who gave me life and encouraged me to pursue my goal…

And my daughter Minnie Zhang
Who gave me so much joy, although sometime drove me crazy…

ABSTRACT

Process improvement programs (PIPs) have been a central research topic in operations management. PIPs can help organizations reduce cost, increase productivity, improve customer satisfaction, grow revenue, and enhance overall competitiveness. However, research on PIPs is extremely difficult. First, widely accepted standard definitions for most PIPs do not exist, and many programs such as Six Sigma and Lean change over time, and are even converging. Second, few firms implement more than one program at the same time, making it difficult to directly compare the efficacy of different programs and to share the learning across programs.

In response to these challenges, this dissertation proposes a more strategic "program management" perspective for the study of PIPs. Process Improvement Program Management (PIPM) is *an organizational approach to defining, planning, implementing, and monitoring a PIP.* PIPM activities include project selection, project prioritization, resource allocation, project management, and learning across projects.

This dissertation identifies three PIPM constructs through an extensive literature review and frequent communication with expert practitioners: Strategic Project Selection (SPS), Disciplined Project Management (DPM), and Buyer-driven Supplier Improvement (BSI). Based on the well-established fit theory, this dissertation hypothesizes that both the internal and external fit relationships between the constructs have strong impact on performance.

This dissertation research adopted the complementary three-essay approach. The first study developed a plant-level measurement instrument for the three PIPM constructs. Multiple responses from supplier plants were examined using confirmatory factor analysis. The results validated the measurement instrument. The second study focused on the internal fit relationship between SPS and DPM. Both constructs were found to positively impact Supplier Operating Performance (SOP), and the relationship between DPM and SOP is partially mediated by SPS. The third study then considered the external fit between BSI and the two internal PIPM constructs. The study revealed that BSI positively impacts SOP and the relationship is also partially mediated by SPS. In short, program management can explain a large portion of the performance variation. PIPM hence is a fruitful research perspective. The studies also revealed the mediating role of SPS, which is a new insight to both the management literature and practice.

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CHAPTER 1
INTRODUCTION

1.1 Motivation

Process improvement programs (PIPs) have been a central research topic in operations management since Frederick Taylor's development of the scientific management in the early 1900's (Hammer, 2002; Silver, 2004; Taylor, 1911). More recently, PIPs such as Total Quality Management (TQM), Six Sigma, and Lean Manufacturing have all been touted as the new "scientific method" for improving productivity and/or quality (Grover and Malhotra, 1997; Rohleder and Silver, 1997; Silver, 2004; Womack and Jones, 2003; Womack, Jones, and Roos, 1991). PIPs have helped organizations achieve benefits such as reducing cost, increasing productivity, improving customer satisfaction, growing revenue, and enhancing overall competitiveness (e.g., Huson and Nanda, 1995; Samson and Terziovski, 1999).

This dissertation defines a process improvement program (PIP) as *a systematic approach for improving organizational performance that consists of specific practices, tools, techniques, and terminology and is implemented as a set of process improvement projects*. Most research studies on PIPs examine one specific type of PIP and attempt to evaluate the relationships between the specific program practices for that PIP and performance. For example, the effectiveness of TQM and Six Sigma programs has been demonstrated by multiple studies (Easton and Jarrell, 1998; Hendricks and Singhal, 1996, 1997, 2001a, b; Kaynak, 2003; Linderman, Schroeder, Zaheer, and Choo, 2003). Similar studies can be found for Lean programs (Shah and Ward, 2003).

One of the fundamental ideas in most PIPs is that a horizontal view (a process view) across organizational boundaries (Hammer and Stanton, 1999) can help find opportunities for process improvement; this suggests that process improvement efforts should be extended across the supply chain. Only recently has the scope of PIP research begun to consider process improvement across the supply chain. Process improvement efforts limited by organizational boundaries will not lead to system-wide optimization (Scott, 1981, 2001; Shafritz and Ott, 1992). In fact, companies such as GE, Motorola, and 3M have expended enormous effort to help their suppliers and customers improve processes (Pande, Neuman, and Cavanagh, 2000). Quality management leaders have also emphasized the importance of working with suppliers to develop a long-term relationship of loyalty and trust (e.g., Deming, 2000). Clearly, research on PIPs in the future should consider inter-firm (supply chain) as well as intra-firm process improvement.

Research on PIPs is extremely difficult due to a number of significant challenges. First, widely accepted standard definitions for most PIPs do not exist in either the research literature or in practice (e.g., Reeves and Bednar, 1994). This challenge is exacerbated by the fact that many process improvement philosophies such as Six Sigma and Lean change over time and are even converging. Research on PIPs is further complicated by the fact that few firms implement more than one program at the same time, which makes is very difficult to have a valid comparison of the efficacy of the different program practices. Consequently, learning across programs is difficult. Findings about one particular practice in one particular program cannot be easily applied to another program.

In response to these challenges, this dissertation proposes a more strategic "program management" perspective for the study of PIPs, which focuses on PIP management activities. This new perspective is termed Process Improvement Program Management (PIPM). PIPM is *an organizational approach to defining, planning, implementing, and monitoring a process improvement program.* PIPM activities include project selection, project prioritization, resource allocation, project management, and learning across projects. Pande, Neuman, and Cavanagh (2000) compare Six Sigma to TQM and ascribe much of the success of Six Sigma programs to the program management. Schroeder, Linderman, Liedtke, and Choo (2004) point out that TQM and Six Sigma share very similar program practices but differ mostly in program management. All PIPs require some sort of program management activities and these activities are critical to program success.

1.2 Research methodology

The goal of this dissertation is to gain novel insights about PIPM and use these insights to inform further theory development effort. This dissertation conducted theory-driven empirical research to gain such novel insights. The studies in this dissertation are explorative in nature because no theory for PIPM has been developed. However, the exploration was guided by the well-established fit theory and followed the protocols of theory-driven empirical research (Amundson, 1998; Handfield and Melnyk, 1998; Melnyk and Handfield, 1998). Therefore, the findings from this dissertation research are grounded in the literature and theoretically sound. The insights can shed light on further theory development effort.

The complementary three-essay approach was adopted to achieve the dissertation research goal. The first essay developed and validated a measurement instrument for three PIPM constructs. The second essay then empirically examined the fit relationship between the two internal PIPM factors and supplier operating performance, using the measurement instrument developed in the first essay. The third essay further extended the investigation to consider the impact of the third PIPM construct, which is an important supply chain contextual factor.

The common goal of the three essays is to identify the form of fit among the PIPM factors. Three PIPM factors were identified in the first essay: Strategic Project Selection (SPS), Disciplined Project Management (DPM), and Buyer-driven Supplier Improvement (BSI). The first essay posited that a fit among the three will lead to PIP effectiveness (i.e. performance improvement), but did not empirically test the relationship. The second essay empirically examined the internal fit relationship between SPS and DPM. The regression analysis used the Supplier Operating Performance (SOP) factor as the dependent variable. The study found that both SPS and DPM have significant positive impact on SOP. The study also revealed that SPS partially mediated the relationship between DPM and SOP. The third essay then focused on the external fit between BSI and the two internal PIPM factors (SPS and DPM). The study found that BSI also has significant positive impact on SOP. The study again showed that SPS partially mediates the relationship between BSI and SOP. The common theme of the dissertation is therefore the mediating role of SPS.

In addition to identifying an important common theme, the three essays complement each other in the research methods used as well. The first essay mainly used the Confirmatory Factor Analysis (CFA) method to examine the validity of the proposed measurement instrument. The second and third essays used various multiple regression methods to analyze the fit relationship among the factors. For the moderation form of fit, Moderated Regression Analysis (MRA) method was used. For the mediation form of fit, the essays followed the procedure suggested by Baron and Kenny (1986). Using different research methods increased the validity of the insights.

1.3 Organization of the dissertation

This dissertation has five chapters. Chapter 1 gives an overview of the dissertation. Chapter 2, 3 and 4 are the three essays. Chapter 5 concludes the dissertation with a summary of the findings. A brief description of the three essays was given below.

Chapter 2 (the first essay) is entitled "Development of a measurement instrument for three process improvement program management constructs." The goal of this essay is to develop and validate a measurement instrument for PIPM. A plant-level measurement instrument was developed and validated following the procedure demonstrated by Flynn, Schroeder, and Sakakibara (1994). First, the three PIPM constructs (SPS, DPM, and BSI) were identified through an extensive review of both academic and practitioner literature and communication with experts. The essay then proposes a conceptual model for the relationship between the factors based on the well-established fit theory. Measurement items were generated and purified through an iterative process. A pilot test was conducted with managers from several Fortune 500 companies before the large-scale empirical validation. Empirical data was collected from 130 supplier plants of one Fortune 500 high-technology electronics manufacturing firm, disguised as High Technology Inc. (HTI), per the confidentiality agreement with the company. The effective sample included 134 responses from 68 supplier plants. CFA validated the construct unidimensionality, reliability, discriminative validity, and convergent validity. Therefore, the proposed measurement instrument can be used in future empirical research. The final version of the measurement instrument included 3 items for SPS, 4 items for DPM, and 3 items for BSI.

Chapter 3 (the second essay) is entitled "The mediating effect of strategic project selection in process improvement program success." The conceptual model developed in Chapter 2 (Essay 1) suggests that the three PIPM factors need to fit with each other for performance. However, the specific form of fit between the factors remains unknown. This essay uses the measurement instrument developed in Essay 1 to empirically examine the form of fit between two internal PIPM factors: SPS and DPM, and the impact of the fit on supplier performance. The fit relationship can be operationalized as moderation or mediation (Venkatraman, 1989). Two competing fit models were subsequently developed based on the literature and logical reasoning. The two models were then empirically examined by a data set that contained complete information of 53 HTI supplier plants. The regression analysis used the SOP factor as the dependent variable, and SPS and DPM factors as independent variables. The reliability of the constructs was examined before the regression analysis. The results showed that both factors positively contribute to SOP, and the mediation model was the most plausible. SPS partially mediated the relationship between DPM and SOP.

Chapter 4 (the third essay) is entitled "Buyer-driven supplier improvement and performance: the mediating role of strategic project selection." This study is a natural extension of the previous one. Essay 2 examined the internal fit between SPS and DPM.

This study considered the impact of Buyer-driven Supplier Improvement (BSI) effort on supplier performance. Guided by the fit theory, this study developed competing moderation and mediation models for the fit relationship between BSI and the two internal PIPM factors (SPS and DPM). Using the same data set from the previous study with additional BSI data, this study empirically examined the two competing models. This study showed that BSI has significant positive impact on SOP, and again that SPS partially mediates the relationship between BSI and SOP.

Finally, Chapter 5 concludes the dissertation with a discussion of the empirical results and their contributions to the theory development and practice. The chapter also addresses the limitations of the dissertation and future research directions.

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CHAPTER 2
DEVELOPMENT OF A MEASUREMENT INSTRUMENT FOR THREE PROCESS IMPROVEMENT PROGRAM MANAGEMENT CONSTRUCTS

2.1 Introduction

Process improvement programs (PIPs) have been a central research topic in operations management since Frederick Taylor's development of the Scientific Management in the early 1900's (Hammer, 2002; Silver, 2004; Taylor, 1911). More recently, PIPs such as Total Quality Management (TQM), Six Sigma, and Lean Manufacturing have all been touted as the new "scientific method" for improving productivity and/or quality (Grover and Malhotra, 1997; Rohleder and Silver, 1997; Samson and Terziovski, 1999; Silver, 2004; Womack and Jones, 2003; Womack, Jones, and Roos, 1991). PIPs have helped organizations achieve benefits such as improving quality, reducing cost, increasing productivity, improving customer satisfaction, growing revenue, and enhancing overall competitiveness. Firms need to continuously improve their processes to successfully compete in an increasingly competitive global market (Pannirselvam, Ferguson, Ash, and Siferd, 1999; Prasad and Babbar, 2000). The interest in studying PIPs continues to grow.

Most research studies on PIPs examine one specific type of PIP and attempt to evaluate the relationships between the specific program practices for that PIP and performance. For example, the effectiveness of TQM and Six Sigma programs has been demonstrated by multiple studies (Easton and Jarrell, 1998; Hendricks and Singhal, 1996, 1997, 2001a, b; Kaynak, 2003; Linderman, Schroeder, Zaheer, and Choo, 2003). Similar studies can be found for Lean programs (Shah and Ward, 2003).

While nearly everyone agrees that research on PIPs is extremely important, most researchers also agree that it is extremely difficult. One of the most significant challenges for research on PIPs is that widely accepted definitions for most PIPs do not exist in either the research literature or in practice (e.g., Reeves and Bednar, 1994). This challenge is exacerbated by the fact that many process improvement programs such as Six Sigma and Lean are converging. Research on PIPs is further complicated by the fact that few firms implement more than one program at the same time, which makes is very difficult to have a valid comparison of the efficacy of the different program practices.

In response to these challenges, this paper proposes a more strategic "program management" perspective for the study of PIPs, which focuses on PIP management activities. Pande, Neuman, and Cavanagh (2000) compare Six Sigma to TQM and ascribe much of the success of Six Sigma programs to the program management. Schroeder, Linderman, Liedtke, and Choo (2006) point out that Six Sigma and TQM share very similar program practices but differ mostly in program management. All PIPs require program management activities and these activities are critical to program success and organizational performance.

The scope of this research paper includes process improvement programs that cross organizational boundaries. This is because organizations are open systems, and any process improvement effort limited by organizational boundaries will not lead to system-wide optimization (Scott, 1981, 2001; Shafritz and Ott, 1992). In fact, companies such as GE and 3M have reaped enormous benefits from their efforts to improve both supplier and customer processes. Supply Chain Management (SCM) is based on a horizontal view of organizations and requires effort and trust across organizational boundaries

(Hammer and Stanton, 1999). Many quality management leaders have emphasized the importance of working with suppliers to develop a long-term relationship of loyalty and trust (Deming, 2000). This research paper, therefore, will consider process improvement programs across the supply chain as well as internal to the firm.

The goal of this paper is to develop and validate a plant-level measurement instrument for PIPM that encompasses collaborative process improvement across the supply chain. Ideally, this measurement instrument will identify valid factors that will have an impact on plant performance. A validated PIPM measurement instrument is a fundamental step toward rigorous empirical investigation. Plants are autonomous organizational units that have well-defined objectives. As a result, plants have been frequently used as the unit of analysis for many operations management studies (Flynn, Sakakibara, Schroeder, Bates, and Flynn, 1990). A plant-level PIPM measurement instrument, therefore, can make a significant contribution to the advancement of research on process improvement programs.

This paper is organized as follows. Section 2 reviews relevant literature and proposes three constructs for PIPM. Section 3 describes how the items for the measurement instrument were generated and refined. Section 4 presents the empirical research design using a web-based survey to collect multiple responses from all supplier plants of an electronics manufacturer. Section 5 reports the validity assessment results using the confirmatory factor analysis (CFA) method. The results show that the proposed measurement instrument is valid and reliable for future empirical studies. The limitation of the study is also discussed. Section 6 concludes the paper with a discussion on the contributions of the study to both theory development and practice.

2.2 Theoretical framework

According to the Project Management Institute, a program is “a group of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually… In contract with project management, program management is the centralized, coordinated management of a group of projects to achieve the program’s strategic objectives and benefits” (PMI Standards Committee, 2004, p. 16). Meanwhile, a project is defined as “a temporary endeavor undertaken to create a unique product, service, or result” (PMI Standards Committee, 2004, p. 5). Building upon this definition, a PIP can be defined as *a systematic approach for improving organizational performance that consists of specific practices, tools, techniques, and terminology and is implemented as a set of process improvement projects.* Well-known PIPs include TQM, Six Sigma, and Lean Manufacturing.

Building on the above definitions, this paper defines Process Improvement Program Management (PIPM) as *the planning, staffing, organizing, monitoring, and controlling of the projects in a process improvement program.* PIPM activities include project selection, prioritization, resource allocation, and chartering. It is worthy noting that these activities extend to the supply chain. The process view of organizations consider cross-organizational collaboration an indispensable part of the whole value creation process. In fact, buyer-supplier collaboration contributes to both the buyer and supplier’s performance (Forker, 1997; Shin, Collier, and Wilson, 2000). All PIPs require program management activities and these activities are critical to program success.

An extensive review of the PIP and SCM research literature and extensive discussions with both academic and practitioner thought leaders identified three important factors -- Strategic Project Selection (SPS), Disciplined Project Management (DPM), and Buyer-driven Supplier Improvement (BSI). The definition and theoretical development for each of these three factors are provided below.

2.2.1 Strategic Project Selection (SPS)

Strategic Project Selection (SPS) refers to *the degree of strategic alignment an organization achieves in selecting and prioritizing process improvement projects*. The best organizations leverage projects as a tool to implement their business strategies (Norrie and Walker, 2004). Project selection and prioritization are critical program management tasks. The level of strategic alignment demonstrated in project selection and prioritization reflects an organization's capability to wisely allocate scarce resources to achieve their most important strategic objectives.

Project selection. The Project Management Institute considers the performing organization's strategic plan a key factor in project initiation and selection decisions (PMI Standards Committee, 2004). Project selection is usually driven by the business strategy and the voice of the customer. Kaplan and Norton's work on strategy mapping argues that strategic initiatives (e.g., projects) should be driven "top-down" from the strategy (Eden and Ackermann, 1998; Kaplan and Norton, 2000, 2004). Griffin and Hauser (1993) demonstrated the importance of the voice of the customer and how the approach can be applied. While these two approaches have slightly different foci, they are generally complementary and can effectively guide organizations to select the most important process improvement projects.

Project prioritization. Not all projects that have been selected should have the same organizational priority; organizations, therefore, must prioritize those projects that have been selected for a process improvement program. Project prioritization is influenced by strategic needs, competitive priorities, market requirements, project sequencing constraints, and resource availability. Project prioritization drives many decisions including start times, timelines, staffing, resource allocation, management attention, and organizational visibility. Good project prioritization helps an organization remain focused on its most important strategic objectives as it allocates scarce organizational resources (Kaplan and Norton, 2000, 2004).

2.2.2 Disciplined Project Management (DPM)

Disciplined Project Management (DPM) refers to *the degree to which an organization applies a consistent, structured, and accountable approach in managing process improvement projects*. This research defines DPM in terms of four variables: (1) full-time process improvement experts, and (2) process improvement project team leaders who are held accountable for project results, (3) a standard process improvement methodology and language, and (4) formal project management methodology embedded in a project charter that defines the project metrics, goals, deliverables, scope, and timeline.

Full-time process improvement experts. Many contemporary process improvement programs such as Six Sigma emphasize deploying full-time process improvement experts. This demonstrates an organization's commitment to the process improvement program, justifies extensive training in process improvement methodologies, helps creates deep experience in process improvement methodologies, and allows for strong accountability for program success (Flynn, Flynn, Amundson, and Schroeder, 1999; Schroeder et al., 2006). In contrast, part-time project leaders tend to find it hard to juggle normal job responsibilities with project responsibilities and often do not have either the training or accountability required for project success.

Accountable process improvement project team leaders. Accountability for results is a key to success for any organizational change. With full-time project leaders, accountability generally comes with the job assignment. However, with part-time project leaders, accountability is really a function of the competence of the project sponsor.

A standard process improvement methodology and language. A standard process improvement methodology and language offers a common framework for problem solving, which makes the organization more efficient at the process of improving processes. A standard methodology and language also facilitates learning across projects (Deming, 2000). Many standard methodologies have been developed, including the well-known PDCA cycle and its latest offspring, the Six Sigma DMAIC method.

Formal project management methodology. The project management literature strongly emphasizes the role of the project charter. The project management best practice is to have a charter that clearly define the project metrics, goals, deliverables, scope, and timeline (Deming, 2000; Pande et al., 2000; PMI Standards Committee, 2004). Meanwhile, the process improvement literature argued that clearly defined goals were critical to the success of a project improvement program (Linderman, Schroeder, and Choo, 2005; Linderman et al., 2003).

2.2.3 Buyer-driven Supplier Improvement (BSI)

A rich body of literature suggests that buyer-supplier collaboration is key to the success of a supply chain (Carr and Pearson, 1999; Lee and Billington, 1992; Vickery, Jayaram, Droge, and Calantone, 2003). This research focuses on a particular type of buyer-supplier collaboration: a buyer firm's effort to help its suppliers improve processes. The Buyer-driven Supplier Improvement (BSI) construct measures *the degree to which a buyer firm reaches out to its suppliers to help them improve their production planning* (Lee, So, and Tang, 2000) *and other supply chain processes.*

Buyer-supplier collaboration has significant performance implications and is an important SCM research topic. In a collaborative relationship, buyers work with suppliers together to solve problems. Quality management leaders (e.g., Deming, 2000) highly promote a collaborative buyer-supplier relationship. Helper (1991; 1995) suggested that much of the competitiveness of Japanese automakers can be ascribed to their collaborative relationship with suppliers. Even indirect suppliers providing commodity type of products benefited from a collaborative relationship with the U.S. automakers (Choi and Hartley, 1996). Several empirical studies have confirmed the positive relationship between buyer-supplier collaboration and performance (e.g., Carr and Pearson, 1999; Johnston, McCutcheon, Stuart, and Kerwood, 2004).

BSI effort is one important type of buyer-supplier collaboration that focuses on process improvement. Several constructs for buyer-suppler collaboration can be found in the SCM literature but none of them specifically measured a buyer's effort in the context of process improvement. The closest match is probably the Supplier Management Orientation (SMO) construct that measures a buyer's "management efforts or philosophy necessary for creating an operating environment where the buyer and supplier interact in a coordinated fashion" (Shin et al., 2000, p. 318). However, the SMO construct has a much broader scope, measuring the overall buyer-supplier relationship but not the process improvement activities. Therefore, a new scale for BSI needs to be developed.

BSI effort can be measured from multiple aspects. First, the BSI construct should include collaboration around improving production planning activities. Clearly, production planning is a core supply chain process and the degree of supplier involvement in the buyer firm's production planning activities reflects the buyer firm's commitment to buyer-supplier process collaboration. Second, the BSI construct should include the buyer firm's effort to involve suppliers in its own process improvement program. Third, the BSI construct should include the buyer's effort to reach out to suppliers to help them improve their processes.

2.2.4 The theoretical model

Fit theory provides an overall framework for understanding both the inter-relationship between the above three factors and their relationship to performance. Classic structural contingency theory posits that the organizational structure must fit the environment for an organization to be effective (Donaldson, 2001). This fit is generally referred to as environmental fit or external fit (Miller, 1992). Later, structural contingency theory was expanded to include the idea of congruency or internal fit (White and Hamermesh, 1981). The central idea of internal fit is that multiple components of a system must fit with each other for the system to have good performance (Miller, 1992; Venkatraman and Camillus, 1984). Although managers sometimes have to make tradeoff between internal and external fit, both types of fit are needed for an organization to be effective (Miller, 1992).

Based on fit theory, the inter-relationship among the factors and the relationship to performance is hypothesized by Fig. 2-1. This research posits that the two internal PIPM constructs, SPS and DPM, need to fit with each other for a PIP to be effective. This research also posits that the internal PIPM constructs (SPS and DPM) need to fit with the external supply chain context (BSI) to raise an organization's performance level.

This paper develops and validates the measurement instrument for the SPS, DPM, and BSI constructs. The creation and empirical testing of more detailed hypotheses related to fit and performance will be left to future research papers.

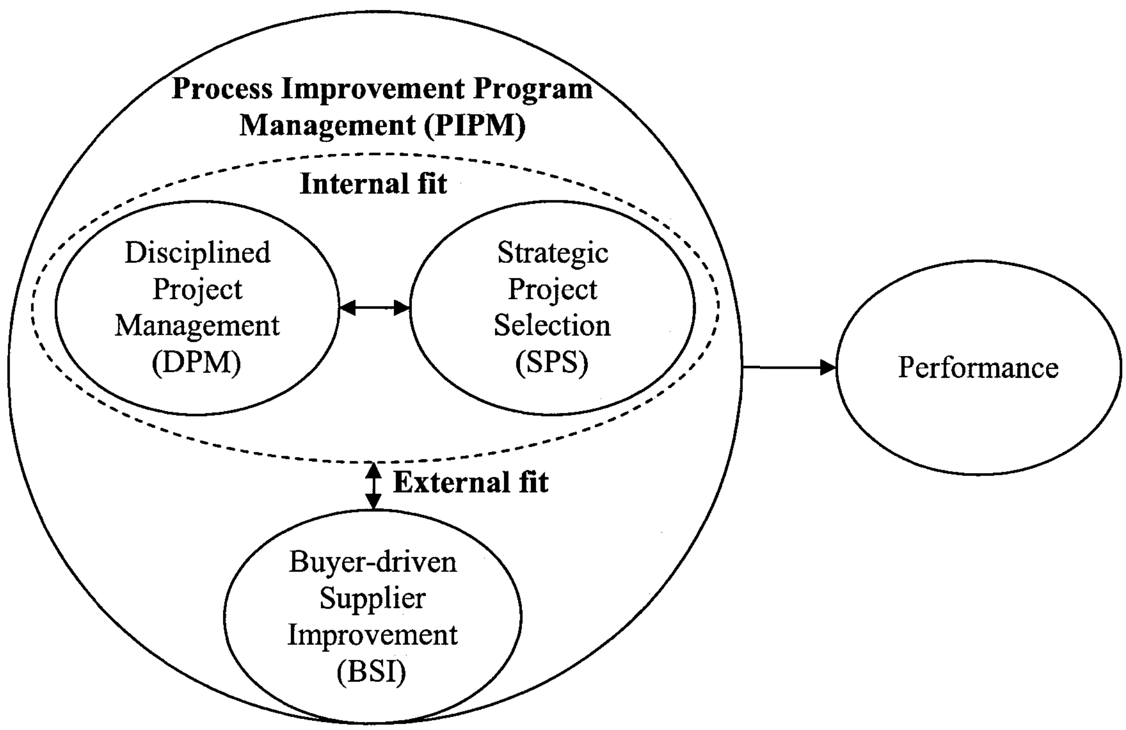

Fig. 2-1. The theoretical model

2.3 Instrument development

Development of a new measurement instrument for PIPM is needed before an empirical test of the performance implications of PIPM can be pursued. Unfortunately, nearly all existing instruments related to process improvement focus on measuring PIP practices rather than program management, although a few measured some aspects of the program management. For example, Ahire, Golhar, and Waller (1996) developed a measurement instrument for TQM implementation. The instrument is different from those measuring TQM practices, but it still did not include important program management tasks such as project selection.

In this research, the development of the PIPM measurement instrument followed the two-stage iterative process demonstrated by Flynn, Schroeder, and Sakakibara (1994) -- scale development and empirical validation. The scale-development stage focused on content validity and established the definitions of the constructs as well as the measurement items for each construct. The definitions of each construct were grounded in the research literature as described above and the items to measure the constructs were also carefully developed based on theory. Items were refined through focus group meetings with research scholars and experienced practicing managers. The item generation-refinement process was guided by the goal of developing a plant-level measurement instrument. Pilot tests were performed at several manufacturing plants and the respondents were interviewed to solicit comments.

In the empirical validation stage, the measurement instrument was refined and validated through a large-scale empirical analysis. The empirical analysis examined unidimensionality, reliability, convergent validity, and discriminant validity. Multiple statistical techniques were applied to examine the psychometric properties of the measurement instrument.

Content validity is the fundamental requirement of the initial item generation. In other words, the measurement items in an instrument should cover the major content of a construct (Churchill, 1979; Nunnally and Bernstein, 1994). Content validity of a measurement instrument is usually achieved through a comprehensive literature review and interviews with very knowledgeable practitioners and scholars.

Focus group meetings were conducted following item generation. The focus group included several research scholars, senior managers from five Fortune 500 companies, and several leading consultants. Focus group members were asked to comment on the appropriateness and the readability of the items. Reviewers were also encouraged to ask as many questions as possible. The focus group feedback helped the research team modify or eliminate redundant and ambiguous items and add new items where needed.

A pilot study was then conducted to assess the initial items. A survey questionnaire was compiled and administered to managers from five Fortune 500 companies. The research team members then interviewed the respondents. The interview focused on assessing whether the items measured what they were intended to measure. In the interview, respondents were first asked to describe their understanding of the questions. Researchers then tried to discern whether a significant discrepancy existed among respondents (degree of agreement), and whether the respondents' understanding diverged significantly from the standard interpretations (ambiguity). Both discrepancies were important aspects of the initial content validity. Degree of agreement was evaluated by the number of different interpretations to the question. Ambiguity was evaluated by the tendency of respondents to change their answers when presented with the standard interpretation. Low agreement and high ambiguity items were carefully refined.

The final version of the measurement instrument included ten items representing the content of the three constructs of interest. All the items used 7-point Likert scale (1=Disagree strongly, 2=Disagree, 3=Disagree somewhat, 4=Neutral, 5=Agree somewhat, 6=Agree, 7=Agree strongly, and N=No response). Using a single scale for all items reduces the complexity of the survey, and therefore, reduces the time required by a respondent. Table 2-1 presents the measurement items used in the subsequent large-scale empirical validation.

Table 2-1
Measurement instrument

Construct	Item
Strategic Project Selection (SPS)	Process improvement projects are generated based on our strategy. We prioritize new process improvement projects based on our strategy. Process improvement project selection is driven by our customers' needs.
Disciplined Project Management (DPM)	Our process improvement projects are led by full-time process improvement experts. Our leadership holds process improvement project team leaders accountable for project results. Our projects use a standard process improvement methodology and language. Our projects have a charter that defines the metrics, goals, deliverables, scope, and timeline.
Buyer-driven Supplier Improvement (BSI)	HTI includes us in their production planning activities. HTI has process improvement programs that include us. HTI helps us improve our processes.

2.4 Empirical research design

Empirical data was collected from the supplier plants of a large high-technology electronics manufacturer. This firm will be referred to as High-Technology Inc. (HTI) hereafter, as per the confidentiality agreement between the firm and the university research team. The university research team and HTI invited supplier plants to participate in a web-based survey. Multiple responses were requested from each plant.

2.4.1 Survey design

HTI is a world-class Fortune 500 electronics manufacturer headquartered in North America with more than 10,000 employees worldwide. It is a world leader in the design and development of high-quality electronic products. HTI considered quality critical to the long-term success and emphasized the concept with its suppliers. Almost all HTI suppliers have implemented one or more process improvement programs.

The supplier base for HTI included a wide variety of suppliers from a number of different industries, making both mechanical and electrical parts, engineered and commodity parts, and high-value and low-value parts. Most suppliers were based in North America with a few of them in Europe and Asia. The size of the suppliers, in terms of the number of employees, also varied significantly. The entire population of plants in this supplier base was surveyed. Although the sample was limited to the suppliers for this one large manufacturer, the variety in the supplier base suggests that the research conclusions should be fairly generalizeable across industries.

A web-based survey was conducted to collect empirical data for this study. The decision was made based on a thorough comparison of web-based and paper-based survey methods (Boyer, Olson, Calantone, and Jackson, 2002). Klassen and Jacobs (2001) suggested five criteria for the comparison: cost, coverage error, response rate, item completion rate, and systematic error. A web-based survey was considered better than (or at least comparable to) other alternatives on all five criteria. The target respondents were professional managers and all had access to the Internet.

The survey website was easy to use. All the survey items were listed on one page using the same 7-point Likert scale. This effectively reduced the cognitive burden on the respondents. The items could be answered by simply clicking radio buttons. Several pilot tests were performed with managers at HTI and other firms, not in the sample, to ensure that the survey could be completed within 10 minutes.

The survey invitation specifically requested three respondents (one sales manager, one manufacturing manager, and one quality manager) from each supplier plant. The goal was to find respondents who had good knowledge about the research subject (Flynn et al., 1990). Having multiple respondents is desirable for studying complex problems because "a multitude of people at all levels are involved with various operating decisions, then efforts to measure competitive priorities [*and other similar constructs*] should encompass a broader scope than a single respondent" (Boyer and Pagell, 2000, p. 365, text in bracket added). Using a single respondent can lead to biased results because of the high risk of receiving a skewed perspective from one individual for a plant (Boyer and Verma, 2000).

A relatively high response rate at the individual level was achieved following the techniques suggested by Frohlich (2002). A high response rate can effectively eliminate the concern of the quality and relevance of the study (Flynn et al., 1990; Malhotra and Grover, 1998). The university research team leveraged HTI's close relationships with its suppliers and had the HTI commodity managers send out the initial survey invitations to the suppliers. The survey website was hosted by the university rather than by HTI. The website clearly stated that HTI did not have access to any individual responses. This strong confidentiality protocol was designed to alleviate concerns about confidentiality that might lead respondents to not respond or to provide a biased response. The university research team actively engaged in the follow-up activities, assuring confidentiality, and promising to share the valuable benchmarking analysis to encourage participation.

2.4.2 Empirical data

All 130 of HTI's supplier plants were invited to participate in the survey. The final complete data set included 134 valid individual responses from 68 supplier plants after eliminating 3 outliers. The response rate is 34.4% at the individual level and 52.3% at the plant level. Table 2-2 presents some characteristics of the sample. Table 2-3 shows the descriptive statistics and correlation among items.

Table 2-2
Sample characteristics

Individual responses	Total individual responses	134
	Individuals from sales	50
	Individuals from manufacturing	40
	Individuals from quality	44
Plant responses	Total number of plants	68
	Number of plants with 4 responses	2
	Number of plants with 3 responses	17
	Number of plants with 2 responses	24
	Number of plants with 1 response	27
	Average number of employees	502

The sample had very few missing data points. Tsikriktsis (2005) suggested that researchers should replace missing values with the mean when the missing values do not demonstrate a systematic pattern. Other researchers have adopted the pair-wise or list-wise deletion approach when the sample size is large. The results reported in this paper are based on the Tsikriktsis (2005) approach; however, the deletion approach yielded almost identical results. Missing values, therefore, were judged to not be a problem.

In order to check for non-response bias, this research collected demographic information from 20 randomly selected non-responding plants. A two-sample t test on the variable of Number of Employees showed no evidence of significant non-response bias ($p = 0.25$).

Table 2-3
Descriptive statistics and correlations

	Variable	*N*	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
	SPS													
1	SPS1	132	5.70	1.14	1.000									
2	SPS2	134	5.84	1.14	0.724***	1.000								
3	SPS3	132	5.65	1.31	0.490***	0.477***	1.000							
	DPM													
4	DPM1	133	5.07	1.74	0.417***	0.482***	0.269**	1.000						
5	DPM2	133	5.30	1.39	0.588***	0.555***	0.429***	0.598***	1.000					
6	DPM3	129	5.23	1.29	0.573***	0.437***	0.418***	0.609***	0.682***	1.000				
7	DPM4	130	5.33	1.44	0.515***	0.464***	0.346***	0.656***	0.724***	0.726***	1.000			
	BSI													
8	BSI1	134	4.78	1.57	0.233**	0.243**	0.265**	0.069	0.156	0.242**	0.209*	1.000		
9	BSI2	108	4.53	1.60	0.194*	0.319***	0.198*	0.211*	0.294**	0.171*	0.247**	0.342***	1.000	
10	BSI3	102	5.10	1.45	0.266**	0.251**	0.364***	0.290**	0.360***	0.380***	0.307***	0.358***	0.531***	1.000

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

All the responses were carefully examined for outliers before further analysis. Additional reverse-scaled items were added to the survey to help detect invalid data from respondents who answered the questions without reading them. A rigorous outlier detection procedure using Mahalanobis Distance (MD) was the performed. A high MD value indicates an outlier (Beguin and Hulliger, 2004; Hosseini, Carpenter, and Mohammad, 1998). The MD follows a Chi-square distribution. Using *p*-value of 0.001 as the cutoff value, SPSS identified 3 responses as outliers. The effective sample size after removing the 3 outliers was 134 individual responses from 68 plants.

2.5 Validity and reliability assessment

Validity of a measurement instrument must be carefully assessed before the instrument can be used for empirical studies. Bagozzi (1980) suggested the following guidelines for assessing the validity of a measurement instrument: (1) content validity, (2) reliability, (3) convergent validity, and (4) discriminant validity. Content validity has already been described above. Reliability reflects the extent to which operational measures are free from random error and measure the construct in a consistent manner (Anderson and Gerbing, 1988). Convergent validity is about the extent to which there is consistency in measurements obtained through different methods (Campbell and Fiske, 1959), typically measured by the extent to which items loaded onto the same construct. Discriminant validity refers to the independence of the constructs (Bagozzi, Yi, and Phillips, 1991), i.e., the extent to which measures of the constructs are distinctly different from each other.

2.5.1 Measurement model

Both Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) are common methods for measurement instrument assessment (Pedhazur and Schmelkin, 1991). EFA is appropriate for exploring the data in search of unidimensional factors, but tends to combine correlated factors into one (Anderson, Gerbing, and Hunter, 1987; Hunter and Gerbing, 1982). In contrast, CFA focuses on assessing the pre-specified item-construct structure through rigorous statistical procedures and is generally considered a better and more powerful method for measurement instrument development (O'Leary-Kelly and Vokurka, 1998; Shah and Goldstein, 2006). CFA, therefore, was selected for this research.

The AMOS software was used to empirically analyze the validity of the measurement instrument. Fig. 2-2 shows the three-construct measurement model. Multiple fit indices of the model are reported in Table 2-4. The results show that the model fits data reasonably well. All items loaded onto the specified factors.

The Chi-square of the model is 56.835 with a degree of freedom of 32. The Chi-square statistic is the most frequently used absolute model fit measure. It measures the difference between the sample covariance and the fitted covariance, and a high score suggests a bad fit. However, this index is sensitive to sample size and departure from multivariate normality (O'Leary-Kelly and Vokurka, 1998). A large sample tends to reject all models including the one that explains most of the variance in the data. Alternatively, a small sample may lead to acceptance of most models. Researchers have alternatively used the ratio of Chi-square to degrees of freedom. The desirable range of the ratio is 1.0 to 3.0 because a small value indicates an over-fitted model and a big value suggests an under-parameterized model (Jöreskog, 1969). The ratio in this study is 1.776.

In addition to Chi-square, multiple absolute fit measures were examined in this study. The goodness-of-fit for a model must be assessed by various fit measures (Byrne, 1989; Hu and Bentler, 1998; Malhotra and Grover, 1998; O'Leary-Kelly and Vokurka, 1998), because this can effectively reduce measurement biases inherent in different measures (Bollen and Long, 1993). Goodness of Fit Index (GFI) indicates the relative amount of variance and covariance jointly explained by the model. Adjusted Goodness of Fit Index (AGFI) differs from GFI in that it adjusts for the number of degrees of freedom in the model. GFI and AGFI values range from 0 to 1, with higher values indicating better fit (Byrne, 1989). GFI and AGFI scores in the 0.80-0.89 range are generally interpreted as representing reasonable fit; scores of 0.90 and above represent good fit (Hair, 1995). In this study, GFI is 0.923 and AGFI is 0.868, suggesting a reasonably good fit.

The Root Mean Square Error of Approximation (RMSEA) measures the discrepancy per degree of freedom. The Root Mean Square Residual (RMR) indicates the average discrepancy between the elements in the sample covariance matrix and the model-generated covariance matrix. Both RMSEA and RMR values range from 0 to 1, with smaller values indicating better models; values below 0.08 are interpreted as acceptable, and values lower than 0.05 signify good fit (Byrne, 1989). RMSEA for the model is 0.076 and standardized RMR is 0.0486, indicating a reasonably good fit.

In addition to the absolute fit measures, the incremental fit measures are reasonably good. The incremental fit measures compare the model to the null and ideal model. Popular incremental fit indices include Normed Fit Index (NFI), Non-normed Fit Index (NNFI or TLI), Comparative Fit Index (CFI) and Incremental Fit Index (IFI). Similar to the absolute fit indices, values of 0.90 or above represent good fit and values in the range of 0.80 to 0.90 signify reasonable fit (Bollen and Long, 1993). All the measures in this study are higher than 0.90. Therefore, the measurement model is judged to be good. The items loaded on to the factors as specified, demonstrating good unidimensionality.

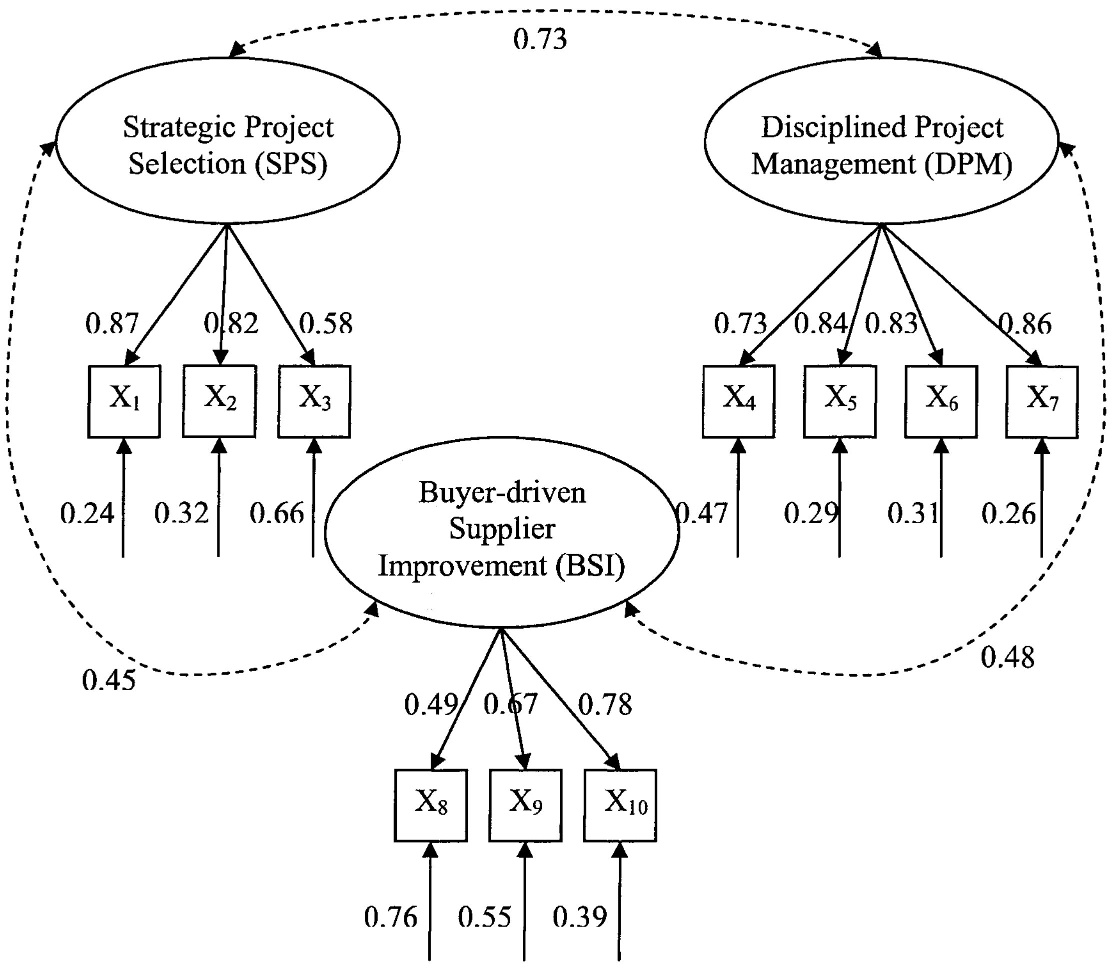

Fig. 2-2. Measurement model

Table 2-4
Model analysis results

Fit Measures	Value
Chi-square	56.835
D.F.	32
RMR	0.0486
RMSEA	0.076
GFI	0.923
AGFI	0.868
NFI	0.914
IFI	0.960
TLI	0.943
CFI	0.960

2.5.2 Reliability

Reliability assesses the consistency or stability of a measure and is inversely related to the degree to which a measure is contaminated by random error (O'Leary-Kelly and Vokurka, 1998). Cronbach's alpha is a commonly used measure of reliability in EFA but it is considered an inferior measure than the composite reliability (CR) index for CFA models (Shah and Goldstein, 2006). A scale is considered reliable if the CR index is 0.70 or higher (Escrig-Tena and Bou-Llusar, 2005; Tanriverdi and Venkatraman, 2005).

Table 2-5 reports the CR indices for all three constructs. For SPS and DPM, the indices are much higher than 0.70, indicating good construct reliability. For BSI, the composite reliability index is slightly lower than 0.70, very acceptable for a new scale.

Table 2-5
Assessment of reliability

Construct	Composite reliability
Strategic Project Management (SPS)	0.809
Disciplined Project Management (DPM)	0.890
Buyer-driven Supplier Improvement (BSI)	0.691

2.5.3 Convergent validity

In this study, convergent validity refers to the principle that the items forming a construct should be at least moderately correlated with each. A measurement scale is considered having good convergent validity when the item-construct correlation coefficients are greater than 0.40. The classic approach of convergent validity assessment is therefore to examine the loading of each item on one scale. Fig. 2. reports all the loadings. For the construct SPS, loadings ranged from 0.58 to 0.87. For DPM, loadings ranged from 0.73 to 0.86. For BSI, the smallest loading is 0.49 and the largest one is 0.78. All the loadings are greater than 0.4, hence the scales are concluded to have good convergent validity.

2.5.4 Discriminant validity

Pair-wise construct structure test were performed to test the discriminant validity. The constructs are considered distinct if the hypothesis that the two constructs together form a single construct is rejected. Test of this hypothesis required setting up two models, one unconstrained and the other one with correlation between the two constructs set to one (Anderson and Gerbing, 1988; Bagozzi et al., 1991). If the difference between the Chi-square values (degree of freedom = 1) of the two models is significant, the two constructs are considered to have discriminant validity (Jöreskog, 1971). The recommended *p*-value is usually 0.05. Table 2-6 reports the results of the three pair-wise tests. The *p*-values of the Chi-square difference are all lower than 0.05. Therefore, the constructs are considered to have discriminant validity.

Table 2-6
Discriminant validity

	Model	Chi-square	Difference	p-value
SPS and DPM	Constrained model	30.4	6.6	0.01
	Unconstrained model	23.8		
SPS and BSI	Constrained model	32.2	5.5	0.02
	Unconstrained model	16.7		
DPM and BSI	Constrained model	25.5	8.4	0.004
	Unconstrained model	17.1		

2.5.5 Limitations

The CFA results show that the proposed measurement instrument is valid with satisfying psychometric properties. However, the sample size limitation of this study needs to be recognized. In determining the required sample size, many researchers used a rule of thumb: 5 times the number of parameters to be estimated. However, the effectiveness of this rule is contingent on several important conditions including multivariate normality and estimation method. A more scientific sample size determining procedure was given by MacCallum, Browne, and Sugawara (1996). The goal of the procedure is to find the ideal sample size that has adequate power for the fit tests (Shah and Goldstein, 2006). This study has a sample size of 134. It is smaller than the ideal sample size, however a calculation based on the MacCallum et al. (1996) procedure suggests that this sample size has sufficient power to distinguish a close-fit model from a mediocre-fit model.

In addition, the empirical data was collected from the direct materials supplier plants for one large high-technology manufacturing firm. The study, therefore, may not be generalizeable beyond the types of suppliers in this sample. Replication of this study to other types of settings and with a larger sample size is needed to address these concerns. It would be interesting, for example, to see if the same three constructs are valid for non-manufacturing organizations such as distributors, retailers, or service firms.

2.6 Conclusions

This paper proposed to study process improvement programs from the program management perspective. Study of process improvement programs has faced two major challenges: commonly accepted definitions for major process improvement programs do not exist in both the research literature and practice, and several major process improvement programs are converging. Both the content validity and discriminant validity of process improvement program studies are threatened. The proposed Process Improvement Program Management (PIPM) perspective can address the challenges. PIPM focuses on the common program management activities that every program requires. The perspective also enables cross-program learning, making it possible to share program management "best practices" across programs.

This paper developed and validated a plant-level measurement instrument for PIPM. The scope of PIPM in this research is not limited by organizational boundaries. It includes both an organization's internal activities and external process improvement effort from the buyers. Three PIPM constructs were identified based on an extensive review of the literature and frequent communication with expert practitioners -- Strategic Project Selection (SPS), Disciplined Project Management (DPM), and Buyer-driven Supplier Improvement (BSI). The paper posits (but does not test) that these three constructs will have a significant impact on performance. Items for each construct was generated and purified through an iterative process involving both scholars and expert practitioners. The whole measurement instrument development and validation process followed the standards in the literature (e.g., Flynn et al., 1994; Saraph, Benson, and Schroeder, 1989).

Empirical data for the study were collected from 68 supplier plants of a major electronics manufacturer. The psychometric properties of the measurement instrument, including unidimensionality, reliability, convergent validity, and discriminant validity, were examined using rigorous statistical procedures. The statistical results confirmed the validity of the proposed measurement instrument. Therefore, the measurement instrument for SPS, DPM, and BSI can be used for future studies of process improvement programs. Eventually, it will be interesting to empirically explore how these three PIPM constructs are related and their impact on competitive advantage and organizational performance.

Development of a valid measurement instrument is an important first step. A valid measurement instrument enables empirical examination of the performance implications of PIPM factors. In-depth understanding of the implications can be a significant contribution to the literature. This development is also expected to motivate and facilitate further theory development and empirical investigation in this field.

This research also contributes to practice. Many managers are perplexed by the problem of selecting the right process improvement program for their organization -- Lean, Six Sigma, Lean Sigma, etc. This study challenges managers to reframe the question in terms of important PIPM factors. While process improvement program selection is important, this research suggests that program management may be even more important. Although the relationship between PIPM factors and performance is yet to be explored, the PIPM measurement instrument offered a valid tool for managers to measure their organization's program management effort.

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CHAPTER 3
THE MEDIATING EFFECT OF STRATEGIC PROJECT SELECTION IN PROCESS IMPROVEMENT PROGRAM SUCCESS

3.1 Introduction

The focus of this research is on Process Improvement Programs (PIPs), which Zhang, Hill, Schroeder, and Linderman (2006) define as *a systematic approach for improving organizational performance that consists of specific practices, tools, techniques, and terminology and implemented as a set of process improvement projects.* Recent PIP research been directed towards Total Quality Management (Easton and Jarrell, 1998; Hendricks and Singhal, 1996, 1997, 2001a, b; Kaynak, 2003; Samson and Terziovski, 1999), Six Sigma (Linderman, Schroeder, and Choo, 2005; Linderman, Schroeder, Zaheer, and Choo, 2003), JIT (Huson and Nanda, 1995), and Lean (Womack and Jones, 2003; Womack, Jones, and Roos, 1991).

While most scholars agree that research on PIPs is extremely important and that the existing research on PIPs has added value to the literature, most scholars also agree that it is extremely difficult to make any strong valid statements about PIPs. One of the most significant challenges for research on PIPs is that widely accepted definitions for most PIPs do not exist in either the research literature or in practice. This challenge is exacerbated by the fact that PIPs tend to change over time, and, in some cases, are even converging (e.g., Lean and Six Sigma). Research on PIPs is further complicated by the fact that few firms implement more than one program at the same time, which makes is difficult (if not impossible) to have a valid comparison of the efficacy of different PIPs in exactly the same business context.

In response to these challenges, this research follows the work by Zhang et al. (2006) and takes a more strategic "program management" perspective for the study of PIPs. They defined Process Improvement Program Management (PIPM) as *the planning, staffing, organizing, monitoring, and controlling of the projects in a process improvement program.* PIPM activities include *project selection, prioritization, resource allocation, and chartering.* Schroeder, Linderman, Liedtke, and Choo (2006) supported the PIPM perspective when they pointed out that Six Sigma and TQM share very similar program practices but differ mostly in program management. This approach is also supported by Pande, Neuman, and Cavanagh (2000) who compared Six Sigma to TQM and ascribed much of the success of Six Sigma programs to program management.

Zhang et al. (2006) proposed two internal PIPM factors, Strategic Project Selection (SPS) and Disciplined Project Management (DPM), and empirically validated a plant-level measurement instrument for these factors. However, that research did not test the relationship between SPS, DPM, and organizational performance. This research tests the relationship between these two factors and organizational performance, and more importantly, also tests how these two factors fit together to improve performance.

Fit theory suggests that the fit between SPS and DPM will lead to performance improvement. However, the specific form of the fit relationship between these two factors has not yet been defined in the literature. Fit can be operationalized as moderation or mediation (Venkatraman, 1989). A clear understanding of the fit relationship between the two factors is needed to further theory development and provide guidance to practicing managers. The goal of this paper, therefore, is to better understand the relationship between the two factors (SPS and DPM) and organizational performance by comparing the two competing forms of fit – moderation and mediation.

This paper is organized as follows. Section 2 briefly reviews the theoretical foundation for the SPS and DPM factors and then contrasts the two competing forms of fit (moderation and mediation). Section 3 describes the empirical research design and the measurement instrument. Sections 4 and 5 describe the research methods, present the empirical results, and discuss the limitations of the research. Section 6 concludes the paper with a discussion of the theoretical and managerial implications.

3.2 Theoretical development

3.2.1 Strategic Project Selection (SPS)

Strategic Project Selection (SPS) measures the degree of strategic alignment an organization achieves in selecting and prioritizing process improvement projects. SPS is reflected in the critical program management tasks of project selection and prioritization. Norrie and Walker (2004) argue that the best organizations are careful to select projects that implement their business strategies. The level of strategic alignment in project selection and prioritization demonstrates an organization's capability to wisely allocate scarce resources to achieve its most important strategic objectives.

The positive impact of SPS on performance is supported by both the project management and strategic management literature. The Project Management Institute (PMI) considers project selection as one of the most important program success factors (PMI Standards Committee, 2004). Strategy scholars point out that the alignment between strategy and its implementation significantly impacts performance (Chandler, 1969; Kaplan and Norton, 2000, 2004; Porter, 1980; Venkatraman, 1989). SPS reflects the degree of alignment hence is positively associated with performance.

While SPS' positive impact on performance is supported by the literature, an empirical examination of this relationship is lacking in the context of process improvement programs. Therefore, this research will empirically test the following hypothesis:

H1: SPS has a positive impact on performance.

3.2.2 Disciplined Project Management (DPM)

Disciplined Project Management (DPM) measures the degree to which an organization applies a consistent, structured, and accountable approach in managing process improvement projects. DPM includes dedicated and accountable improvement specialists (Flynn, Flynn, Amundson, and Schroeder, 1999; Schroeder et al., 2006) and a standard process improvement methodology with a project charter that defines the project metrics, goals, deliverables, scope, and timeline (Deming, 2000; Pande et al., 2000; PMI Standards Committee, 2004).

The positive impact of DPM on performance is supported by the project management literature. A project typically consists of multiple interdependent tasks. Without a disciplined approach to project management, projects will not meet their stated objectives and not be completed on time and within budget (Eckes, 2003; Gray and Larson, 2000).

The positive association between DPM and performance is also supported by the quality management literature. Well-known standard project management methodologies such as PDCA and DMAIC emphasize a disciplined approach to project management and encourage rational decision making. Rational decisions, in general, will lead to positive outcomes (Churchman, 1962; Goll and Rasheed, 1997; Latane, 1959; Simon, 1979). One important aspect of DPM is a project charter that clearly defines the project objectives.

The goal theoretical perspective suggests that clearly defined objectives (goals) can help explain the success of Six Sigma programs (Linderman et al., 2003). In a recent follow-up study, Linderman, Schroeder, and Choo (2005) established a positive association between Six Sigma methods, tools adherence, and project success. Their research provides strong support for the positive association between DPM and performance.

Overall, strong support can be found for the positive relationship between standard project management methodology, dedicated improvement specialists, and project success. Aggregated project successes over many projects should contribute to organization level performance. This research hypothesizes, therefore, that:

H2: DPM has a positive impact on performance.

3.2.3 The fit between SPS and DPM

Structural contingency theory (Donaldson, 2001) provides a framework to understand the relationship between SPS and DPM. A key idea of this theory is that the various components of a system must fit with each other for the system to achieve performance (Miller, 1992; Venkatraman and Camillus, 1984). This research posits that SPS and DPM represent two different aspects of process improvement program management and that they need to fit together in order for a process improvement program to be successful. Fig. 3-1 depicts this theoretical model in its simplest form.

The form of fit is essential to he meaning of the theory itself (Van de Ven, 1979; Van de Ven and Drazin, 1985; Venkatraman, 1989). A review of the literature suggests that two competing forms of fit are both reasonable: moderation and mediation. These two forms of fit are in the criterion-specific group in the framework developed by Venkatraman (1989). Forms of fit in the criterion-free group are irrelevant to this study because the goal of this research is to investigate the impact of fit on performance. The next two sections discuss these two competing forms of fit.

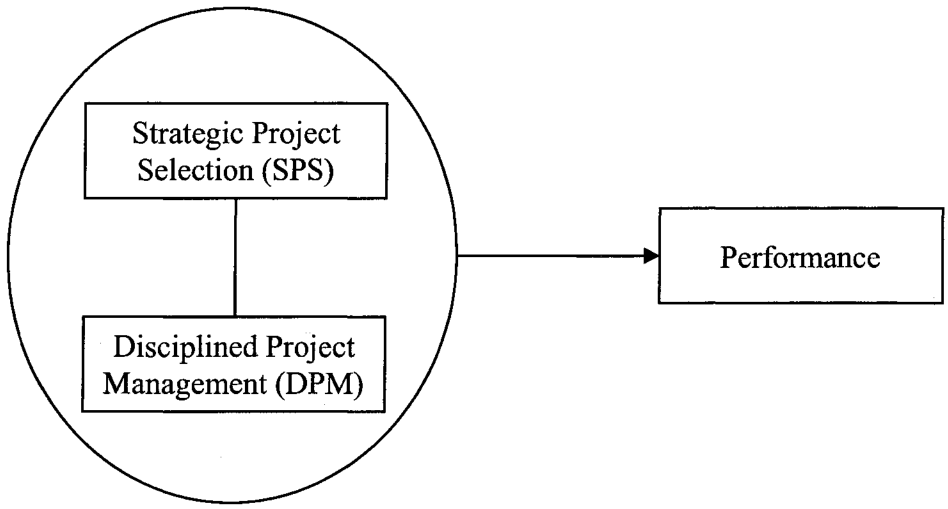

Fig. 3-1. The general fit model

3.2.3.1 Fit as moderation

Fit can be operationalized as moderation. Moderation means the relationship between an independent variable and a dependent variable is dependent on the level of a third variable, the moderator (Hair, 1995; Venkatraman, 1989). The fit between the independent variable and the moderator is the key determinant of the dependent variable. A moderator can affect the direction or the strength of the relationship between an independent and a dependent variable.

One plausible fit model is that SPS positively moderates the relationship between DPM and performance. First, there exists a positive relationship between DPM and project success. As mentioned earlier, this relationship is strongly supported by both the academic and practitioner literature. The aggregated project successes can contribute to organizational performance. However, the strength of this relationship depends on how projects are selected. Strategically selected projects support an organization's mission and such project successes can quickly translate into organization-level performance. In contrast, the success of many trivial projects may have little or no impact on organizational-level performance. Simply equating the sum of individual project successes to organization-level performance is what Robinson (1950) called an "ecological fallacy" because the two are at different levels.

In short, the strength of the relationship between DPM and organizational performance will be stronger when SPS is high, or vice versa, i.e., SPS positively moderates the relationship. This is depicted in Fig. 3-2 below and reflected in Hypothesis H3.

H3: The relationship between DPM and performance is positively moderated by SPS.

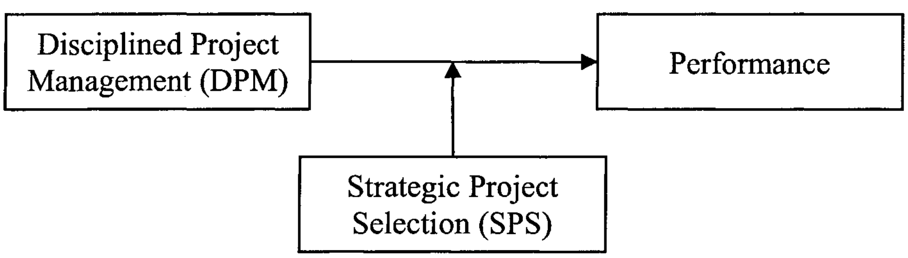

Fig. 3-2. The moderation model

3.2.3.2 Fit as mediation

Fit can also be operationalized as mediation. Mediation means that the effect of an independent variable on a dependent variable is intervened by a third variable, the mediator. The theoretical basis for the mediation model is the existence of a cause and effect relationship along the chain of the three variables (Baron and Kenny, 1986).

The mediation model posits that SPS mediates the relationship between DPM and performance. The causal link between DPM and SPS is supported by two arguments. First, DPM promotes a highly disciplined, analytical, and fact-based organizational culture that encourages a structured project selection process. The argument is that an organization that is good at DPM will lean toward having a structured analytical process for difficult decisions such as project selection and prioritization. The second argument is that the causal link is also supported by the motivation and reward system for project leaders. DPM promotes the idea of using dedicated project leaders and holding them accountable for project results. Dedicated project leaders are motivated to select strategic process improvement projects so they can bring significant results to their organization and earn positive performance reviews for themselves. It stands to reason, therefore, that higher DPM will lead to higher SPS, which will in turn lead to better performance. The full mediation model is depicted in Fig. 3-3 and stated in hypothesis H4.

H4: The relationship between DPM and performance is mediated by SPS.

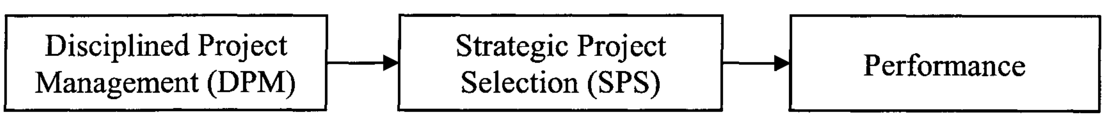

Fig. 3-3. The full mediation model

When studying mediation models, it is necessary to distinguish between a full and a partial mediation model. In a full mediation model, the relationship between the independent variable and the dependent variable is completely mediated by the mediator. In a partial mediation relationship, the independent variable still has some direct effect on the dependent variable in addition to the mediated effect through the mediator (Fig. 3-4). For the mediating relationship between DPM, SPS and performance, the literature does not clearly favor either the full or partial mediation model; therefore, analysis of the empirical data will show whether mediation is present, and if so, which model is most plausible.

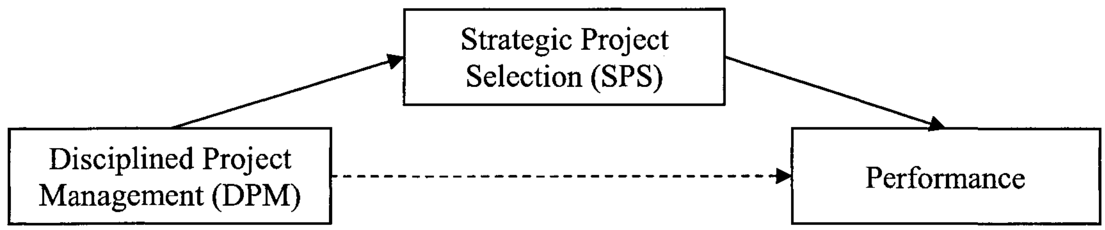

Fig. 3-4. The partial mediation model

3.3 Empirical research design

3.3.1 The population

Plant-level empirical data was collected from the suppliers of a large high-technology electronics manufacturer. This firm will be referred to as High-Technology Inc. (HTI) hereafter, as per the confidentiality agreement between the firm and the university research team. HTI is a world-class Fortune 500 electronics manufacturer headquartered in North America with more than 10,000 employees worldwide. It is a world leader in the design and development of high-quality electronics products. HTI considered quality to be critical to its long-term success and emphasized this concept with its suppliers.

Almost all HTI suppliers have implemented one or more process improvement programs. The direct materials suppliers for HTI included a wide variety of suppliers from a number of different industries, making both mechanical and electrical parts, engineered and commodity parts, and high-value and low-value parts. Most suppliers were based in North America with a few of them in Europe and Asia. The size of the suppliers, in terms of the number of employees, also varied significantly.

The entire population (130) of direct materials supplier plants was surveyed. Although the sample was limited to the suppliers for this one large manufacturer, the variety in the supplier base suggests that the research conclusions should be fairly generalizeable across industries. The university research team and HTI together invited supplier plants to participate in a web-based survey. Multiple responses were requested from each plant, with invitations sent to managers in manufacturing, quality, and sales. The HTI buyer group evaluated all supplier plants to measure their performance.

3.3.2 Survey design

A web-based survey was conducted to collect empirical data for this study. The decision was made based on a thorough comparison of web-based and paper-based survey methods (Boyer, Olson, Calantone, and Jackson, 2002). Klassen and Jacobs (2001) suggested five criteria: cost, coverage error, response rate, item completion rate, and systematic error. The target respondents were professional managers and all had access to the Internet. A web-based survey was considered better than (or at least comparable to) other alternatives on all five criteria.

All the questions on the survey website were listed on one page using the same 7-point Likert scale to reduce the cognitive burden on respondents. The questions can be answered by simply clicking radio buttons. Several pilot tests were performed with managers at HTI and other firms not in the sample to ensure that the survey could be completed within 10 minutes.

The survey invitation specifically requested three respondents (one sales manager, one manufacturing manager, and one quality manager) from each supplier plant. The goal was to find respondents who had good knowledge of the research subject (Flynn, Sakakibara, Schroeder, Bates, and Flynn, 1990). Having multiple respondents is desirable for studying complex problems because "a multitude of people at all levels are involved with various operating decisions, then efforts to measure competitive priorities [and *other similar constructs]* should encompass a broader scope than a single respondent" (Boyer and Pagell, 2000, p. 365, text in bracket added). Using a single respondent can lead to biased results because of the high risk of receiving a skewed perspective from one individual in a plant (Boyer and Verma, 2000).

A high response rate was achieved following the techniques suggested by Frohlich (2002). Response rate measures the quality and relevance of a study and a low response rate immediately raises the concern of nonresponse bias (Flynn et al., 1990; Malhotra and Grover, 1998). The university research team leveraged HTI's close relationships with its suppliers and had the HTI commodity managers send out the initial survey invitations to suppliers. The survey website was hosted by the university rather than by HTI and the website clearly stated that HTI did not have access to any individual responses. This strong confidentiality protocol was designed to alleviate concerns about confidentiality that might lead respondents to not respond or to provide a biased response. The university research team actively engaged in the follow-up activities, assuring confidentiality, and promising to share the valuable benchmarking analysis to encourage participation.

3.3.3 Empirical data

All 130 direct materials supplier plants of HTI were invited to participate in the survey. The final complete data set included 104 valid individual responses from 53 plants, achieving a response rate of 40.8% at the plant level. Table 3-1 presents some characteristics of the sample.

Table 3-1
Sample characteristics

Individual responses	Total individual responses	104
	Individuals from sales	37
	Individuals from manufacturing	34
	Individuals from quality	33
Plant responses	Total number of plants	53
	Number of plants with 4 responses	2
	Number of plants with 3 responses	17
	Number of plants with 2 responses	11
	Number of plants with 1 response	23
	Average number of employees	544

No evidence of significant non-response bias was found in the data. Some previous studies checked for nonresponse bias by comparing early to late responses, assuming that late respondents represented non-respondents (Armstrong and Overton, 1977; Lambert and Harrington, 1990). This research collected demographic information from 20 randomly selected non-responding plants. A two-sample *t* test on this data showed no evidence of significant nonresponse bias ($p = 0.34$).

Using multiple raters is more difficult in empirical studies but it can provide "a greater degree of methodological rigor, thus leading to a greater degree of confidence in the findings" (Boyer and Verma, 2000, p. 129). However, to obtain the benefits, researchers must carefully assess the inter-rater reliability measures. The Interclass Correlation (ICC) measures for the SPS and DPM factors were both greater than the suggested 0.6.

3.3.4 Measures

SPS and DPM were measured using the instrument developed by Zhang et al. (2006). The measurement instrument was developed and validated through a rigorous process similar to that of Flynn, Schroeder, and Sakakibara (1994). All the items in the measurement instrument used the same 7-point Likert scale (1=Disagree strongly, 2=Disagree, 3=Disagree somewhat, 4=Neutral, 5=Agree somewhat, 6=Agree, 7=Agree strongly, and N=No response). Ahire et al. (1996) argue that the 7-point scale is better than a 5-point scale because of its capability to capture more variation. Additional reverse items were used to detect invalid data from respondents who answered questions without reading them. The large-scale empirical test using the Confirmatory Factor Analysis (CFA) method supported the validity of the instrument (Zhang et al., 2006). Table 2 shows the items for the SPS and DPM constructs.

The dependent variable for this study was the Supplier Operating Performance (SOP) factor. Operating performance is typically measured in five dimensions: quality, cycle time, delivery, cost, and flexibility (Benson, Cunningham, and Leachman, 1995; Ferdows and De Meyer, 1990). The scales used by Ahire et al. (1996) were adapted for this study. Their scale was anchored on the worst companies in the industry and was essentially a reversed scale. This research asked the HTI buyers to give their evaluation of supplier performance on all five performance dimensions compared to the "best in the industry" (see Table 3-2).

Multiple responses from the same plant were first averaged to obtain one observation for that plant. Then the validity of the measurement instrument was examined statistically with SPSS. Principal Components Analysis (PCA) with the Varimax rotation was performed to determine scale unidimensionality. Finally, Cronbach's alpha for all three scales was examined.

SPS consists of three items. Cronbach's alpha for the SPS scale was 0.694, clearly exceeding the minimum acceptable standard of 0.6 suggested by Nunnally and Bernstein

(1994). PCA found that all three SPS items loaded onto a single factor. The eigenvalue was 1.893, higher than the minimum acceptable level of 1.0. The SPS factor explained 63.1% of the variation. The factor loadings for all the items ranged from 0.604 to 0.898, all above the acceptable lower bound of 0.4 (Carmines and Zeller, 1979).

Table 3-2
Measurement instrument

Construct	Item	*N*	Mean	S.D.
Strategic Project Selection (SPS)	Process improvement projects are generated based on our strategy.	53	5.67	0.93
	We prioritize new process improvement projects based on our strategy.	53	5.80	0.88
	Process improvement project selection is driven by our customers' needs.	53	5.74	0.93
Disciplined Project Management (DPM)	Our process improvement projects are led by full-time process improvement experts.	53	4.98	1.65
	Our leadership holds process improvement project team leaders accountable for project results.	52	5.51	1.13
	Our projects use a standard process improvement methodology and language.	53	5.37	1.18
	Our projects have a charter that defines the metrics, goals, deliverables, scope, and timeline.	52	5.55	1.24
Supplier Operating Performance (SOP)	This supplier has the best internal first pass yield rate in the industry.	42	4.64	1.18
	This supplier's throughput time is the best in the industry.	51	4.35	1.37
	This supplier's delivery performance is the best in the industry.	53	5.04	1.51
	This supplier has the best unit cost in the industry.	53	4.37	1.22
	This supplier has the best ability to quickly adjust production capacity in the industry.	52	4.46	1.26

DPM consists of four items. The DPM scale had a Cronbach's alpha of 0.868, much higher than the minimum value of 0.6. All four items loaded onto a single factor and the loadings ranged from 0.794 to 0.913. The eigenvalue associated with the scale was 2.938. The DPM factor explained 73.4% of the variation.

The SOP factor consists of five items. However, factor analysis showed that all five items except for the cost item loaded onto one factor. Therefore, cost was dropped from the factor. The cost item is the price as seen by the HTI buyers. Suppliers' prices are affected by many different factors such as the plant's total volume, market position vis-à-vis its competitors, product technology, process technology, and many other factors that have little to do with supplier operating performance (Hendricks and Singhal, 2001a). The cost item, therefore, was excluded from the performance factor. Cronbach's alpha for SOP with four items was 0.689. Items loadings ranged from 0.437 to 0.921. The eigenvalue was 2.108. The factor explained 52.7% of the variation (see Table 3-3).

HTI buyers evaluated SOP for each plant. This avoided problems that can occur with common method bias. Common method biases occur when the variance is attributable to the measurement method rather than to the constructs that the measures represent (Campbell and Fiske, 1959). It is most likely to occur in survey research when all variables are collected from the same informants. With common method bias, the validity of the conclusions is threatened because it is hard to tell whether the relationships represent the reality or just the respondents' perception (Podsakoff, MacKenzie, Lee, and Podsakoff, 2003). Having different informants for the independent and dependent variables eliminates concern about common method bias and increases the credibility of the results.

Table 3-3
The SPS, DPM and SOP factors

		SPS	DPM	SOP
Cronbach's Alpha		0.694	0.868	0.689
Factor loadings				
	Item 1	0.898	0.794	0.773
	Item 2	0.850	0.869	0.921
	Item 3	0.604	0.913	0.685
	Item 4		0.847	0.437
Eigenvalue		1.893	2.938	2.108
Variation explained		63.1%	73.4%	52.7%

Once factor analysis confirmed the validity of all three scales, the factor scores for each construct were calculated using regression in SPSS. Hair (1995) noted that factor scores are "composite measures for each factor representing each subject ... Conceptually speaking, the factor score represents the degree to which each individual scores high on the group of items that load high on a factor ... these scores are saved for further use in subsequent analyses." (p. 390). The subsequent regression analyses used factor scores.

Finally, organizational size has been recognized as a critical control variable in empirical studies. Daft (2000) suggested that "because organizations are social systems, size is typically measured by number of employees" (p. 18). Because the distribution of Number of Employees (EMP) was highly skewed (as expected), a natural log transformation was applied following Neter, Kutner, Nachtsheim, and Wasserman (1996).

3.4 Methods

This study used the ordinary least squares (OLS) regression method. Moderated Regression Analysis (MRA) was used to test the moderation hypothesis. In addition, the Baron and Kenny (1986) procedure was used to test the mediation model. All assumptions of OLS regression were examined before any conclusions were drawn.

3.4.1 Moderated Regression

Testing the moderation effect by MRA requires the addition of an interaction term in the regression equation. The interaction term is the cross product of factors scores of SPS and DPM in this study. If the interaction term is statistically significant, the moderation hypothesis is supported. Because all regression assumptions were met, it was appropriate to add the interaction term to the models.

Venkatraman (1989) cautioned researchers that the MRA method should only be used when the research hypothesis states that the outcome is jointly determined by the interaction of the independent variable and moderator. In contrast, if the research hypothesis is that the impact of the independent variable on outcome differs across different levels of the moderator, subgroup analysis is more appropriate. Since the hypothesis states that it is the interaction between SPS and DPM that determines the performance level, MRA is the appropriate method.

3.4.2 Mediation model test method

Testing mediation models is more complicated than that of moderation models. Baron and Kenny (1986) and Judd and Kenny (1981) suggested a general procedure for testing mediation using multiple regression, illustrated in Fig. 3-5. The procedure has four steps with the fourth step being optional. The steps are:

Step 1: Conduct a regression analysis to show that the independent variable (IV) is correlated with the dependent variable (DV) (path *C).* A statistically significant correlation is the prerequisite for a mediation model to hold.

Step 2: Show that the IV is correlated with the mediation variable (MV) (path *A).* Path *A* must be significant for the mediation model to hold.

Step 3: Show that the MV affects the DV by regressing the DV on both the IV and MV together. Regressing the DV on the MV only is insufficient because the MV and the DV may be correlated if the IV causes them both. Thus, the IV must be controlled when establishing the effect of the MV on the DV.

Step 4: To establish that the MV fully mediates the IV-DV relationship, the effect of the IV on the DV controlling for the MV (path *C'*) should be zero, otherwise a partial mediation model is supported.

Mediation is supported when all the paths (except *C'*) are statistically significant, provided that the causal links among variables are established by the theory. Step 4 is only required to test for the full mediation effect. If the IV no longer has any effect on the DV when the MV has been controlled, the full mediation has occurred. If the coefficient of path *C'* is different from zero, the effects can be partitioned into direct and indirect effects. Statistical significance of path *C'* is irrelevant in Step 4 because trivially small coefficients can be statistically significant with large sample sizes and very large coefficients can be insignificant with small sample sizes (Baron and Kenny, 1986).

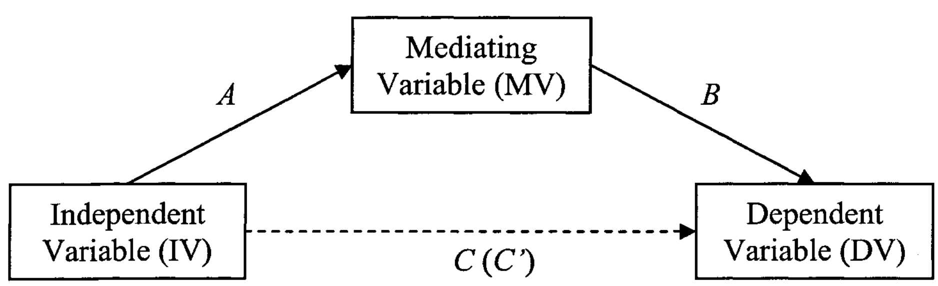

Fig. 3-5. The mediation model test

To establish a mediation relationship, it is important to rule out other possible models that are consistent with the data. One possibility is the reverse causal effects, that is, the MV is, in fact, caused by the DV. Because regression analysis does not assume causality, it is not possible to rule out this alternative model simply by evaluating the regression results. However, a reversed causal effect is not a concern in this study because the reversed causal link (SOP → SPS) is not supported by the literature or logical reasoning.

One important methodological issue is whether the IV should be controlled in Step 3. James and Brett (1984) argued that Step 3 should be modified by not controlling for the IV. Their rationale is that if there is full mediation, there would be no need to control for the IV. However, full mediation does not always occur. In this study it is more sensible to control for the IV in Step 3 so that the empirical results can reveal whether the full or partial mediation model is most plausible.

Although the above steps can be used to informally judge whether mediation is occurring or not, a formal assessment will involve statistical tests (MacKinnon, Warsi, and Dwyer, 1995). The mediation effect is also called an indirect effect and is defined as the reduction of the effect of the IV on the DV, mathematically, $c - c'$, where c and c' are the coefficients for paths *C* and *C'* respectively. Studies have shown that the reduction is theoretically the same as the product of the coefficient of the IV on the MV times the coefficient of the MV on the DV, mathematically, $c - c' \approx ab$, where a and b are the coefficients for path *A* and *B* respectively, when there are no missing observations (Baron and Kenny, 1986). A test of the null hypothesis of $ab = 0$ can reveal whether a mediation effect is present. Although it is possible to test both $a = 0$ and $b = 0$ simultaneously with the appropriate family alpha level, a single test is preferred (MacKinnon, Lockwood, Hoffman, West, and Sheets, 2002).

The most commonly used test is the Sobel (1982) test, which is a z test, with two major variants. This test is based on the fact that the standard error of ab is approximately the square root of *b2Sa2* + *a2Sb2*. The two major variants are Aroian and

Goodman (Sobel, 1982). The difference is whether the term *Sa2Sb2* is included in the denominator or not. The Aroian version is recommended by some scholars because it does not make the unnecessary assumption that the product *Sa2Sb2* is vanishingly small. The Goodman version of the test subtracts the third term for an unbiased estimate of the variance of the mediated effect, but this can sometimes have the unfortunate effect of yielding a negative variance estimate. The Sobel test and the Aroian test seemed to perform the best in a Monte Carlo study, and converge closely with a sample size greater than 50 (MacKinnon et al., 1995). This study performed all three tests and found the same results for all three (see Table 5). The equations for these three tests are given below.

$$z = \frac{ab}{\sqrt{b^2 S_a^2 + a^2 S_b^2}}$$
Sobel version

$$z = \frac{ab}{\sqrt{b^2 S_a^2 + a^2 S_b^2 + S_a^2 S_b^2}}$$
Aroian version

$$z = \frac{ab}{\sqrt{b^2 S_a^2 + a^2 S_b^2 - S_a^2 S_b^2}}$$
Goodman version

3.4.3 Multicollinearity

Multicollinearity is an important analytical issue in regression. When two or more independent variables are highly correlated with each other, the overall fit of the model to the data will not change significantly but estimation of individual coefficients can be significantly comprised (Hair, 1995). Usually with multicollinearity, the estimation of the standard error of individual coefficients is not stable and is biased toward enlargement. This can lead to incorrectly concluding that an important variable is statistically insignificant

In analyzing both the moderation and mediation models, multicollinearity is expected. In moderation models, the interaction term is likely to be strongly correlated with the independent variables. However, it is worth noting that although statistical estimations might be problematic due to multicollinearity, establishing the existence of moderation effects is not a problem (Venkatraman, 1989). In fact, simple transformation of variables such as centering can reduce the level of correlation between the interaction term and the original variables, hence decreasing the negative impact of multicollinearity.

In mediation models, multicollinearity exists by definition. For a mediation model to hold, the IV is correlated with the MV, hence the estimation of the coefficients of path *B* and *C'* is compromised. The Variance Inflation Factor (VIF) and a large sample can be used to manage the issue. VIF measures the impact of collinearity among the independent variables in a regression model on the precision of estimation. It expresses the degree to which collinearity among the independent variables degrades the precision of an estimate. In general, a high VIF suggests an unstable regression analysis and the resultant estimation is invalid. However, different disciplines have suggested different cutoff values. Hair et al. (1995) suggested a cutoff value of 10, whereas many social science disciplines suggest 4. All VIF values reported in the regression analyses in this study were lower than 2. Multicollinearity, therefore, was judged not to be a problem in this study.

3.5 Results and Discussion

3.5.1 Results

The means, standard deviations, and correlations of the variables under consideration are displayed in Table 3-4. The effect of the control variable is examined first, followed by the hypotheses in order.

Table 3-4
Descriptive statistics and correlationsa

	Variable	*Nb*	Mean	S.D.	1	2	3	4
1.	SOP	53	0	1	1.000			
2.	SPS	53	0	1	0.492***	1.000		
3.	DPM	53	0	1	0.407**	0.620***	1.000	
4.	Ln(EMP)	49	5.223	1.357	0.254	0.067	0.282	1.000

[a] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[b] Sample size adjusted for missing data.

Table 3-5 provides the results of the regression analysis. Model 1 gives the regression of the control variable on the performance variable, which is insignificant (F = 3.236, p = 0.078). This suggests that HTI buyers' evaluation of supplier plant performance was independent of plant size. Model 2 examines the individual contribution of SPS on performance. The model is highly significant (F = 10.198, p = 0.000) with a positive coefficient for SPS, suggesting that SPS is positively associated with performance. The *R2* is a very decent 30.7%. Therefore, hypothesis H1 is supported. Similarly, Model 3 examines the individual contribution of DPM on performance. The model is also highly significant (F = 5.553, p = 0.007) with a positive coefficient for DPM. Therefore, hypothesis H2 is supported. DPM is positively associated with performance.

Model 5 examines the moderation hypothesis. The cross product of SPS and DPM is added to the model. The model is highly significant (F = 5.532, p = 0.001); however, the coefficient for the interaction term is not significant (p = 0.234). The analysis does not find support for the moderation effect of SPS. Hypothesis H3 is not supported.

A test of the mediation hypothesis requires several simultaneous regression analyses as suggested by Baron and Kenny (1986). First, Model 3 shows that DPM is positively associated with performance. This establishes the basis that there could be an effect to be mediated. Model 6 then shows that SPS and DPM are positively correlated (F = 31.845, $p = 0.000$). Finally, Model 4 shows that the coefficient of DPM is smaller than that of Model 3 when the mediator SPS is added. This pattern informally suggests the existence of mediation effect from SPS. The three formal Sobel tests reached the same conclusion, statistically confirming the mediating role of SPS. Hypothesis H4, therefore, is supported.

3.5.2 Discussion

These empirical results confirm that both SPS and DPM are important factors in the effectiveness of process improvement programs. Individually, each is significantly correlated with SOP. This result confirms both the content and predictive validity of the constructs. Empirical results further reveal that the inter-relationship between the two factors is best described by a partial mediation model rather than a moderation model. The moderation hypothesis is not supported, suggesting that the effect of DPM on SOP is not moderated by SPS. Instead, the mediation hypothesis is supported. Overall, a higher level of DPM will lead to both a higher level of SPS and a higher level of SOP, and a higher level SPS further contributes to SOP.

The coefficient of DPM in Model 4 is smaller than in Model 3. This size reduction is key to the establishment of the mediation effect. The coefficient, although smaller, is not close to zero. This suggests that a partial mediation model is more appropriate than a full mediation model. While SPS mediates the relationship between DPM and SOP, DPM still has some direct effect on SOP.

This study shows that DPM has a positive impact on performance. This is in line with the Linderman et al. (2005) study in which the authors demonstrated a strong positive link between Six Sigma method adherence to project success. This study differs from theirs in that it uses organization level as opposed to project level performance measures. This study further reveals the partial mediation relationship at the organizational level. However, it is not clear whether the same hypothesis will be supported at the project level. Robinson (1950) showed that findings at the individual level may not be generalized to the group level without careful validation, or vice versa. Otherwise one would commit the mistake of "ecological fallacy." Multi-level studies are needed to address such questions.

3.5.3 Limitations

Two limitations of this study need to be acknowledged. First, empirical data for this study was from supplier plants for one large high-tech firm. The study, therefore, may not be generalizeable beyond the types of suppliers found in this study. Replication of this study is needed to address this concern. Second, the sample size (N = 53 plants) was not large. A larger sample size would provide for more statistical power and also enable the use of more powerful statistical methods such as Structural Equation Models.

Table 3-5
Regression results

	DV = SOP										DV = SPS	
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	β	*t*	*β*	*t*	*β*	*t*	*β*	*t*	*β*	*t*	*β*	*t*
Intercept	-1.017	-1,800	-0.85	1.725	-0.581	-1.051	-0.757	-1.454	-0.779	-1.503	0.000	0.000
Ln(EMP)	0.188	1.799	0.164	1.793	0.110	1.073	0.146	1.515	0.135	1.403		
SPS			0.505	4.015***			0.446	2.781*	0.505	3.025**		
DPM					0.375	2.725**	0.097	0.596	0.134	0.811	0.620	5.643***
SPS × DPM									0.145	1.206		
R2	6.4%		30.7%		19.4%		31.3%		33.5%		38.4%	
F	3.236		10.198		5.553		6.822		5.532		31.845	
p	0.078		0.000		0.007		0.001		0.001		0.000	
N	49		49		49		49		49		53	

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

Sobel test: 2.495, $p = 0.013$
Aroian test: 2.464, $p = 0.014$
Goodman test: 2.527, $p = 0.012$

3.6 Conclusions

This research began with a definition of process improvement programs (PIPs) and the program management mechanism for PIPs. The research posited that two process improvement program management (PIPM) factors, Strategic Project Selection (SPS) and Disciplined Project Management (DPM), had significant impact on performance. The research further posited that SPS and DPM need to fit with each other to achieve performance, but raised the question of the nature of that fit. The paper then developed four hypotheses dealing with relationships between SPS, DPM, and Supplier Operating Performance (SOP), with emphasis on the form of fit between the two factors.

A large-scale empirical study was conducted in collaboration with the largest division of a large high-tech electronics firm that allowed the research team to survey its key suppliers. This study did not ask respondents to identify which process improvement programs they had implemented. This approach avoided the difficult definitional issues around specific process improvement programs such as Six Sigma and emphasized management issues that are shared by all process improvement programs.

The majority of the 53 plants in the sample provided multiple respondents. The analysis of empirical data strongly supported the posited relationship between both factors (SPS and DPM) and Supplier Operating Performance (SOP). More importantly, the empirical results found that DPM and SPS both had a significant impact on SOP and that SPS partially mediates the relationship between DPM and SOP.

This study makes several contributions to the literature. First, the study empirically confirms the validity of the PIPM research perspective: how process improvement programs are managed has a significant impact on the program effectiveness. Second, this is the first paper to empirically test the relationships between two PIPM factors (SPS and DPM) and performance. The empirical results show that the two factors can explain a large portion of the variation in performance. The validity of the PIPM research perspective is thus empirically confirmed and the research perspective can now be used to explain some of the differences in program success for process improvement programs. The study shows that SPS and DPM are generalizeable "best practices" for process improvement program management, independent of which process improvement program is implemented. Third, the study contrasts two common forms of fit and finds that SPS partially mediates the effect of DPM on performance. This is the first research study to identify the mediating role of SPS in process improvement programs.

This research also provides some guidance for practicing managers. Many managers are perplexed by the problem of selecting the right process improvement program for their organization -- Lean, Six Sigma, Lean Sigma, etc. This study challenges managers to reframe the question in terms of PIPM factors SPS and DPM. While process improvement program selection is important, this research suggests that program management may be even more important. This study also challenges practicing managers to re-think the role of both SPS and DPM. Leading Six Sigma consultants and successful business leaders have emphasized DPM in the practitioner literature (e.g., Bossidy, Charan, and Burck, 2002). However, this body of literature has never explored the relationships between SPS, DPM, and performance. An important message for the managers from this study is that DPM as defined in this research will promote a highly disciplined organizational culture and positively influence SPS. This approach suggests that managers should focus on creating a disciplined project management environment (e.g., full-time and accountable project leaders with a standard methodology and strong charters). This disciplined culture will then, in turn, drive the organization to select projects strategically, which will then, in turn, lead to improved performance customers can measure.

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CHAPTER 4
BUYER-DRIVEN SUPPLIER IMPROVEMENT AND PERFORMANCE: THE MEDIATING ROLE OF STRATEGIC PROJECT SELECTION

4.1 Introduction

A process improvement program (PIP) is a systematic approach to identifying, selecting and managing a set of process improvement projects to improve organizational performance. The significance of PIPs has been widely recognized by both academics and practitioners and it is well-accepted that PIPs can successfully help organizations improve quality, reduce cost, increase productivity, improve customer satisfaction, grow revenue, and enhance overall competitiveness (e.g., Grover and Malhotra, 1997; Huson and Nanda, 1995; Linderman, Schroeder, and Choo, 2005; Samson and Terziovski, 1999; Womack, Jones, and Roos, 1991).

Researchers pursuing research on PIPs are faced with a number of significant challenges, including (1) few organizations implement more than one PIP at a time, which makes it difficult to compare the effectiveness of different PIPs, (2) PIPs often have definitions that are not universally accepted, and (3) the content of PIPs tends to change over time. As a result of these and other challenges, it has been very difficult for researchers to make strong statements about the efficacy of any one PIP.

In response to these challenges, Zhang, Hill, Schroeder, and Linderman (2006a) proposed a new research perspective for the study of PIPs, which they called the "Process Improvement Program Management" (PIPM) perspective. The PIPM perspective focuses on program management activities that all PIPs have in common, such as planning, staffing, organizing, monitoring, and controlling of the projects in a process improvement program.

The usefulness and validity of the PIPM perspective were confirmed in an empirical study (Zhang, Hill, Schroeder, and Linderman, 2006b) that showed that two internal PIPM factors, Strategic Project Selection (SPS), and Disciplined Project Management (DPM) have significant positive impact on supplier performance. More importantly, that study found that the relationship between DPM and performance is partially mediated by SPS. In other words, a large portion of the impact from DPM on performance is through SPS.

While the Zhang et al. (2006b) work contributed to the novel understanding of the mediating role of SPS, that study only considered internal PIPM factors and did not consider supply chain contextual factors. However, almost all process improvement programs extend across organizational boundaries. The contemporary view is that organizations are open systems and that process improvement effort limited by organizational boundaries will not lead to system-wide optimization (Scott, 1981, 2001; Shafritz and Ott, 1992). Therefore, this paper will explore the performance implications of PIPM effort across organization boundaries.

Buyer-supplier collaboration is a critical supply chain management (SCM) activity that has significant performance implications (Carr and Pearson, 1999). Buyer-driven Supplier Improvement (BSI) effort is one type of buyer-supplier collaboration focusing on process improvement. This paper is one of the first to test the impact of BSI effort on supplier performance. This study also empirically examined the fit relationship between BSI and the two internal PIPM factors.

This research is guided by the well-known fit theory. Fit theory provides a useful research framework to study the two important relationships: the relationship among internal components of a system (internal fit); and the relationship between external contextual factors and internal structural variables (external fit) (Donaldson, 2001; Miller, 1992; White and Hamermesh, 1981). This study focuses on the external fit. The goal of this study is to empirically discern the specific form of fit and its impact on supplier performance.

This paper is organized as follows. Section 2 presents the theoretical models. Two competing models of fit relationship are developed based on the literature review and logical reasoning. This section also presents the research hypotheses. Section 3 describes the empirical research design and the measurement items. Sections 4 and 5 describe the research methods and present the empirical results, and discuss the limitations of the research. Section 6 concludes the paper with a discussion of the theoretical and managerial implications, and directions for future research.

4.2 Theoretical development

4.2.1 The conceptual model

The Process Improvement Program Management (PIPM) perspective is needed to explore the efficacies across different PIPs. First, studying PIPs from program management perspective avoids the difficult definitional issues. Definition is a first step in scientific studies. However, widely accepted definitions for most PIPs do not exist in either the research literature or practice. Studies advocating the effectiveness of one PIP may be challenged on content validity. Second, many process improvement philosophies such as Six Sigma and Lean are converging. The studies may be criticized of lack of discriminant validity. However, all PIPs require program management activities and these activities are critical to program success and organizational performance.

The practitioner literature has suggested that program management significantly impacts performance. For example, in the case of Six Sigma, Pande, Neuman, and Cavanagh (2000) compare Six Sigma to TQM and ascribe much of the success of Six Sigma to its program management. Schroeder, Linderman, Liedtke, and Choo (2006) point out that Six Sigma and TQM share very similar program practices but differ mostly in program management. These observations support the notion that PIPM may be a fruitful approach for research on PIPs.

Zhang et al. (2006a) recently proposed a three-factor conceptual model and used the fit theory to explain the relationship among the factors and their implication on performance. Fig. 4-1 depicts the conceptual model. The three PIPM factors in the model are Strategic Project Selection (SPS), Disciplined Project Management (DPM), and Buyer-driven Supplier Improvement (BSI).

SPS measures the degree of strategic alignment an organization achieves in selecting and prioritizing process improvement projects. Norrie and Walker (2004) pointed out that best organizations leverage projects as a tool to implement their business strategies. Project selection and prioritization therefore are critical program management tasks. The level of strategic alignment demonstrated in project selection and prioritization reflects an organization's capability to wisely allocate scarce resources to achieve the most important strategic objectives. The positive association between SPS and performance is strongly supported in the literature. In fact, the Project Management Institute considers project selection one of the most important program management tasks

(PMI Standards Committee, 2004). From the strategic management perspective, SPS reflects the degree of alignment in the implementation of strategy. A high SPS means a good alignment of strategy and implementation and it will lead to good performance (Chandler, 1969; Porter, 1980; Venkatraman, 1989).

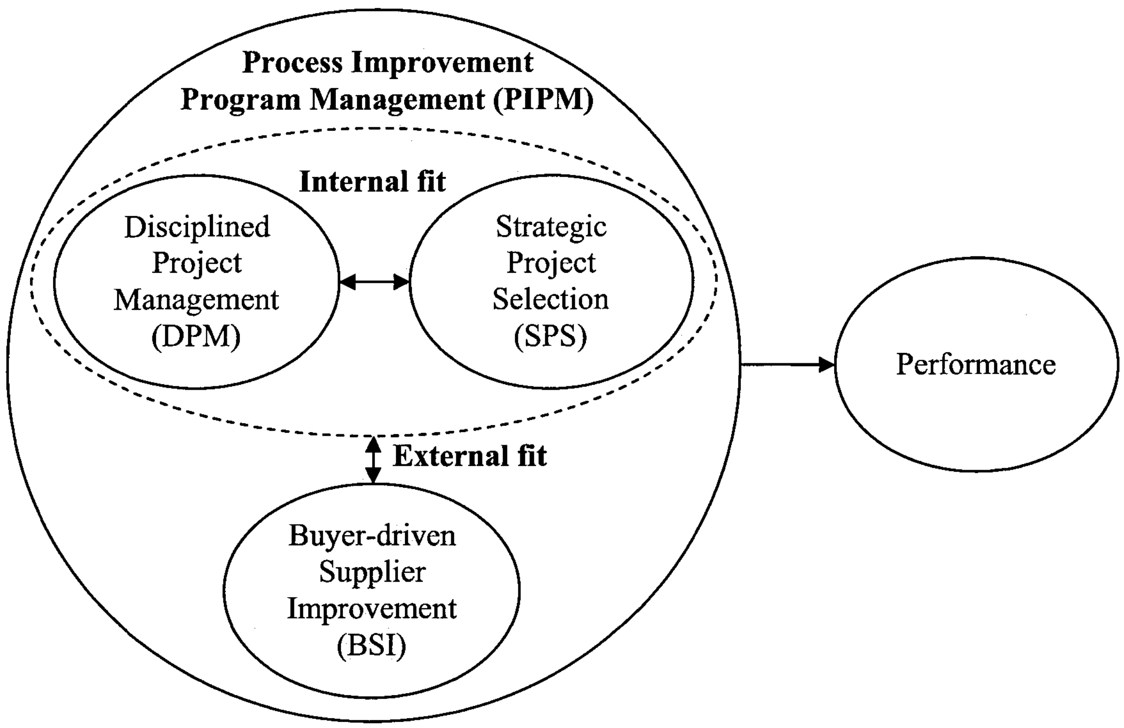

Fig. 4-1. The conceptual model

DPM measures the degree to which an organization applies a consistent, structured, and accountable approach in managing process improvement projects. DPM includes dedicated improvement specialists (Flynn, Flynn, Amundson, and Schroeder, 1999; Schroeder et al., 2006) and standard project implementation methodology (Deming, 2000; Pande et al., 2000; PMI Standards Committee, 2004). DPM reflects the thoughts of rational decision making and rational decision making is considered to have a positive impact on outcome (Churchman, 1962; Goll and Rasheed, 1997; Latane, 1959; Simon, 1979). Standard project management methodology helps reduce the complexity of project planning, scheduling and resource allocation, and contributes to successful completion of the project on time and within budget (Linderman et al., 2005; Linderman, Schroeder, Zaheer, and Choo, 2003; PMI Standards Committee, 2004).

Conceptually, the relationship between SPS and DPM can be characterized as "internal fit." Zhang et al. (2006b) studied the form of the internal fit using empirical data collected from multiple supplier plants. The study confirmed that both factors are positively associated with supplier performance. Then the study evaluated two possible forms of fit: moderation and mediation (Venkatraman, 1989). The empirical results showed that the mediation model is most plausible model. The form of the internal fit is that SPS partially mediates the relationship between DPM and performance. A high DPM will lead to both a high SPS and good performance, and the resultant high SPS will further contribute to performance. The partial mediation model is depicted by Fig. 4-2.

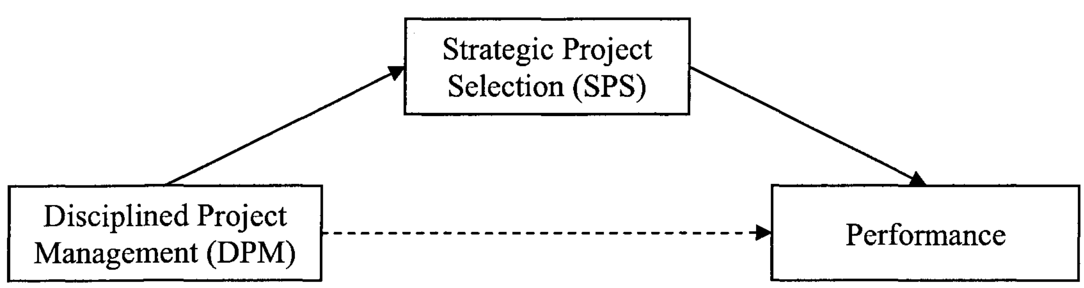

Fig. 4-2. The internal fit between DPM and SPS: a partial mediation model

While the discovery of the mediating role of SPS is an important and novel insight, it is equally important to consider the external fit – the fit between supply chain contextual factors and internal PIPM factors. One important supply chain contextual factor is the Buyer-driven Supplier Improvement (BSI) effort. This study considers the fit between BSI and the two internal PIPM factors, and the impact of that fit on performance.

4.2.2 Buyer-driven Supplier Improvement (BSI)

Buyer-driven Supplier Improvement (BSI) refers to a buyer firm's effort that crosses its organizational boundaries to reach out to the suppliers, often involves sharing production planning information (Lee, So, and Tang, 2000) and helping suppliers improve their processes. BSI measures the degree of buyer-supplier collaboration in the context of process improvement.

Buyer-supplier collaboration has significant performance implications and is an important SCM research topic. In a collaborative relationship, buyers work with suppliers together to solve problems. Quality management leaders (e.g., Deming, 2000) highly promote a collaborative buyer-supplier relationship. Helper (1991; 1995) suggested that much of the competitiveness of Japanese automakers can be ascribed to their collaborative relationship with suppliers. Even indirect suppliers providing commodity type of products benefited from a collaborative relationship with the U.S. automakers (Choi and Hartley, 1996). Several empirical studies have confirmed the positive relationship between buyer-supplier collaboration and performance (e.g., Carr and Pearson, 1999; Johnston, McCutcheon, Stuart, and Kerwood, 2004).

BSI effort is one important type of buyer-supplier collaboration that focuses on process improvement. In the ideal case of collaborative process improvement, suppliers are involved in the buyer firm's production planning activities, and the buyer firm will include suppliers in their process improvement activities, and if needed, reach out to the suppliers to improve their processes. These activities will have positive impact on supplier performance. The relationship between BSI effort and supplier performance is summarized as hypothesis H1:

H1: BSI is positively associated with supplier performance.

4.2.3 The external fit

While the BSI effort is expected to lead to supplier performance, it is necessary to recognize that BSI is an external contextual factor to the supplier plants. A more important relationship is therefore the "external fit" (Donaldson, 2001), the fit between BSI and the two internal PIPM factors, SPS and DPM. Fit theory suggests that two competing forms of fit are both reasonable: moderation and mediation. These two forms of fit are in the criterion-specific group in the classificatory framework developed by Venkatraman (1989). This study uses supplier performance as the criteria to judge the impact of fit. The next two sections describe the two competing forms and develop testable hypotheses. Empirical data is then used to test the two forms to find the most plausible one.

4.2.4 Fit as moderation

The form of fit between BSI and the two PIPM factors can be operationalized as moderation. Moderation means the relationship between an independent variable and a dependent variable is dependent on the level of a third variable, the moderator (Hair, 1995; Venkatraman, 1989). The fit between the independent variable and the moderator is the key determinant of the dependent variable. A moderator can affect the direction or the strength of the relationship between an independent and a dependent variable.

Either internal PIPM factors can be a moderator for the relationship between BSI and supplier performance. It is also possible that both factors can be moderators simultaneously. The literature does not favor any one of the three possibilities. Therefore, three separate moderation models are developed and each has a testable hypothesis.

In the first model, SPS alone assumes the moderator role. This is possible because the impact of BSI on supplier performance must be realized via the supplier's process improvement projects. When the projects are strategically selected, BSI will impact the critical processes and the strength of performance implications will be stronger. In contrast, many trivial projects will not effectively translate the BSI effort into performance improvement. In short, the relationship can be stated as hypothesis H2a and depicted by Fig. 4-3.

H2a: The relationship between BSI and supplier performance is positively moderated by SPS.

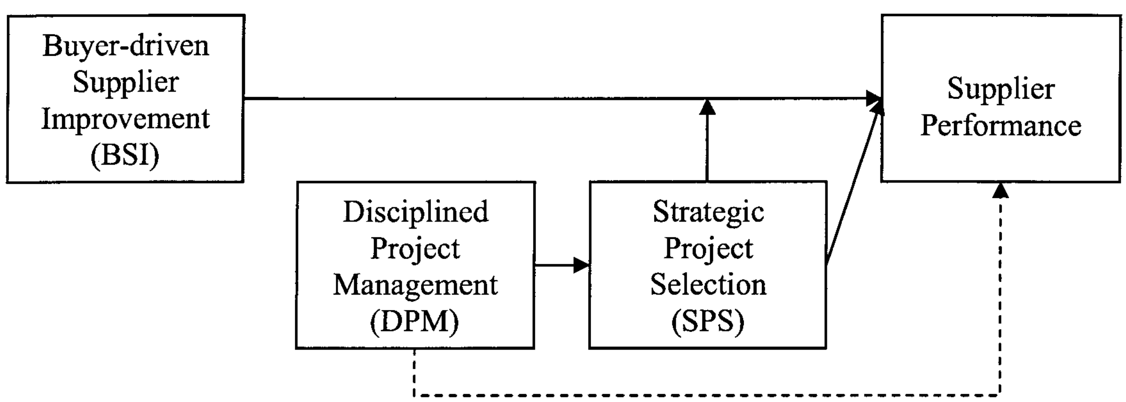

Fig. 4-3. Moderation model 1

It is also possible that the relationship between BSI and supplier performance is positively moderated by DPM. DPM measures how disciplined an organization manages the improvement projects. Disciplined projects have higher chances to be successful. The argument for the positive moderation effect of DPM is similar to that of SPS, the link between BSI and supplier performance will be stronger if the improvement projects are managed in a disciplined and accountable way. The relationship can be stated as hypothesis H2b and depicted in Fig. 4-4.

H2b: The relationship between BSI and supplier performance is positively moderated by DPM.

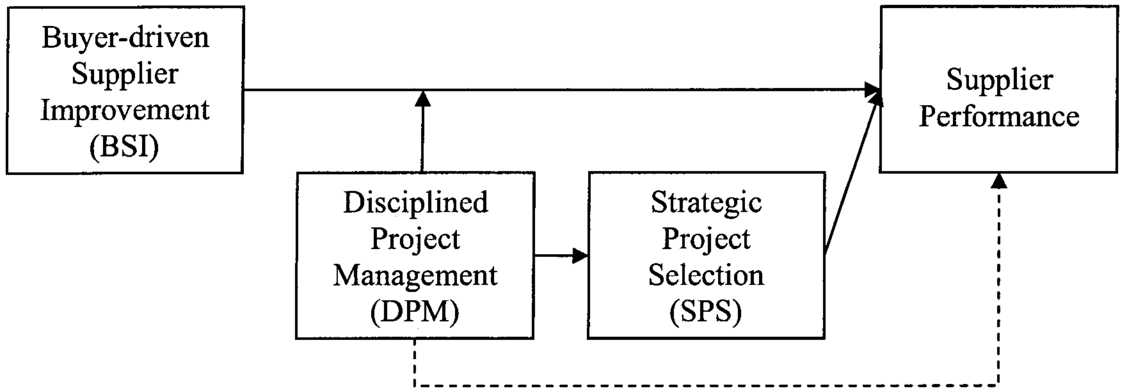

Fig. 4-4. Moderation model 2

Finally, it is possible that both SPS and DPM positively moderate the relationship between BSI and supplier performance. In fact, hypothesis H2b suggests that SPS could simultaneous be a moderator because DPM will lead to SPS (Zhang et al., 2006b). When DPM assumes a moderator's role, SPS is likely a moderator for the same relationship. This leads to hypothesis H2c and the relationship is depicted in Fig. 4-5.

H2c: The relationship between BSI and supplier performance is positively moderated by both SPS and DPM.

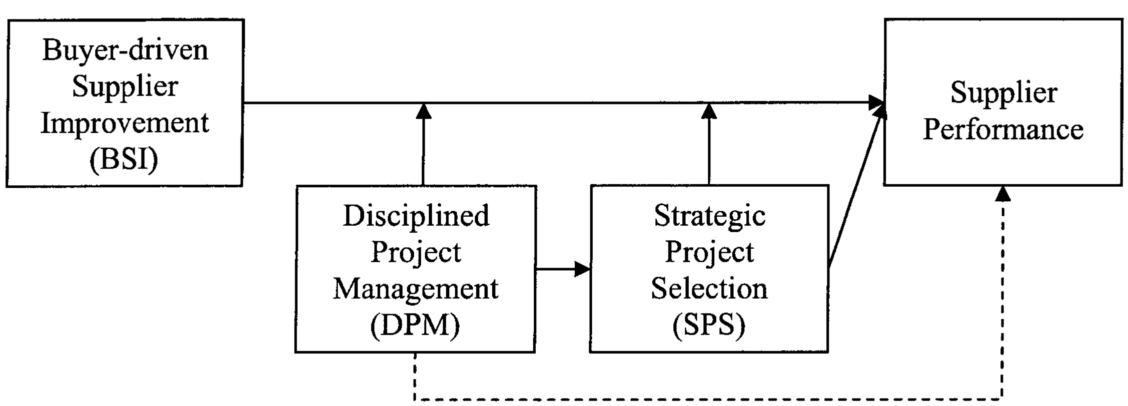

Fig. 4-5. Moderation model 3

In addition to the three moderation models, a possible fourth model is the higher order moderation model. In the model, the relationship between BSI and supplier performance is moderated by the cross-product of SPS and DPM. Although the model is mathematically possible, it is out of consideration because of its lack of theory basis. The previous study already showed that SPS partially mediates but not moderates the relationship between DPM and performance, a cross-product of SPS and DPM is therefore theoretically meaningless.

4.2.5 Fit as mediation

The external fit relationship can also be operationalized as mediation. Mediation means that the effect of an independent variable on a dependent variable is intervened by a third variable, the mediator. The theoretical basis for the mediation model is the existence of cause-effect chain among the three variables (Baron and Kenny, 1986).

The cause-effect link between BSI and SPS suggests that the form of external fit could be mediation. BSI measures the strength of the buyer's effort. With a high BSI, sensitive production planning information from the buyer is shared with the supplier, and the buyer will reach out to the supplier to help them improve processes. This will strengthen the collaborative relationship between the buyer and the supplier. Suppliers will be able to select the improvement projects more strategically based on the customer's needs. It is reasonable to expect a high BSI leads to a high SPS at the supplier side. And a high SPS will contribute to performance. The relationship is stated as hypothesis H3 and depicted in Fig. 4-6.

H3: The relationship between BSI and supplier performance is mediated by SPS.

The mediation model also includes the other PIPM factor DPM although the literature does not support a causal link from BSI to DPM. This is necessary because SPS was found to partially mediate the relationship between DPM and supplier performance in the previous study (Zhang et al., 2006b). The Baron and Kenny (1986) mediation model test procedure suggests that the effect of other variables must be controlled for a correct estimation of the mediation effect interested. Therefore, to correctly assess the mediation effect of SPS on the relationship between BSI and performance, DPM is included in the model as a control variable.

It is not clear from the literature whether the effect of BSI will be fully or partially mediated by SPS. A full mediation means that all the effect of BSI on supplier performance is mediated by SPS. A partial mediation means that there is still some direct effect from BSI on supplier performance despite the indirect effect that is mediated by SPS. The current literature does not favor one model over the other. The empirical analysis will show which model is the most plausible.

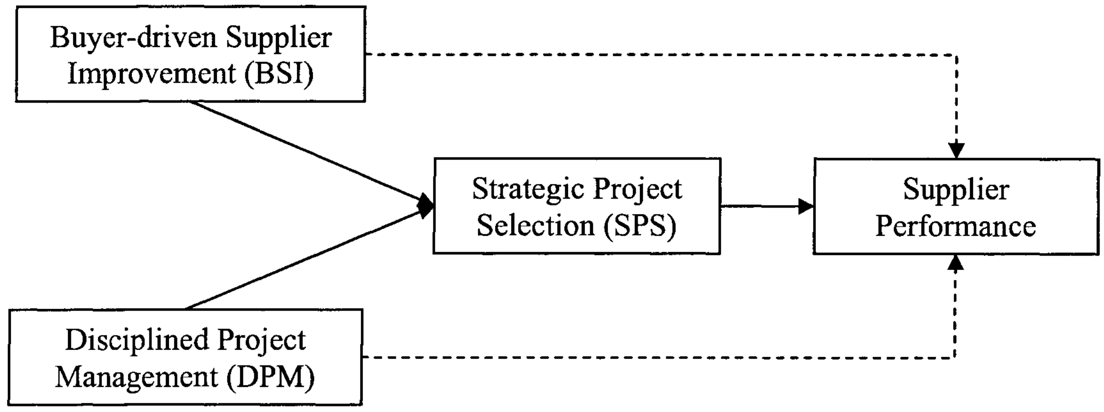

Fig. 4-6. The mediation model

4.3 Empirical research design

4.3.1 The population

This paper used the same data set as Zhang et al. (2006b) with additional data collected on BSI. The data set contained plant-level data from the suppliers of a large high-technology electronics manufacturer whose name will be disguised as High-Technology Inc. (HTI), per the confidentiality agreement between the firm and the university research team. The university research team and HTI invited supplier plants to participate in a web-based survey. Multiple responses were requested from each plant. The HTI buyer group evaluated all supplier plants to measure supplier performance.

HTI is a world-class Fortune 500 electronics manufacturer headquartered in North America with more than 10,000 employees worldwide. It is a world leader in the design and development of high-quality electronic products. HTI considered quality critical to the long-term success and emphasized the concept with its suppliers. Almost all HTI suppliers have implemented one or more process improvement programs.

The entire population (130) of direct materials supplier plants was surveyed. The supplier base for HTI included a wide variety of suppliers from a number of different industries, making both mechanical and electrical parts, engineered and commodity parts, and high-value and low-value parts. Most suppliers were based in North America with a few of them in Europe and Asia. The size of the suppliers, in terms of the number of employees, also varied significantly. Although the sample was limited to the suppliers for this one large manufacturer, the variety in the supplier base suggests that the research conclusions should be fairly generalizeable across industries.

4.3.2 Survey design

Empirical data was collected through a web-based survey. Web-based survey was selected based on a thorough comparison to the paper-based survey methods (Boyer et al., 2002). Klassen and Jacobs (2001) suggested five criteria: cost, coverage error, response rate, item completion rate, and systematic error. The target respondents were professional managers and all had access to the Internet. A web-based survey was considered better than (or at least comparable to) other alternatives on all five criteria.

The survey website was easy to use. All the survey items were listed on one page using the same 7-point Likert scale. This effectively reduced the cognitive burden on the respondents. The items could be answered by simply clicking radio buttons. Several pilot tests were performed with managers at HTI and other firms not in the sample to make sure that the survey could be completed within 10 minutes.

The survey invitation specifically requested three respondents (one sales manager, one manufacturing manager, and one quality manager) from each supplier plant. The goal was to find respondents who had good knowledge about the research subject (Flynn et al., 1990). Having multiple respondents is desirable for studying complex problems because "a multitude of people at all levels are involved with various operating decisions, then efforts to measure competitive priorities [*and other similar constructs*] should encompass a broader scope than a single respondent" (Boyer and Pagell, 2000, p. 365, text in bracket added). Using a single respondent can lead to biased results because of the high risk of receiving a skewed perspective from one individual for a plant (Boyer and Verma, 2000).

A high response rate was achieved following the techniques suggested by Frohlich (2002). Response rate measures the quality and relevance of a study and a low response rate immediately raises the concern of non-response bias (Flynn et al., 1990; Malhotra and Grover, 1998). The university research team leveraged HTI's close relationships with its suppliers and had the HTI commodity managers send out the initial survey invitations to suppliers. The survey website was hosted by the university rather than by HTI and the website clearly stated that HTI did not have access to any individual responses. This strong confidentiality protocol was designed to alleviate concerns about confidentiality that might lead respondents to not respond or to provide a biased response. The university research team actively engaged in the follow-up activities, assuring confidentiality, and promising to share the valuable benchmarking analysis to encourage participation.

4.3.3 Empirical data

All 130 direct materials supplier plants of HTI were invited to participate in the survey. The final complete data set included 104 valid individual responses from 53 plants. The response rate is 40.8% at the plant level. Table 4-1 presents some characteristics of the sample.

Table 4-1
Sample characteristics

Individual responses	Total individual responses	104
	Individuals from sales	37
	Individuals from manufacturing	34
	Individuals from quality	33
Plant responses	Total number of plants	53
	Number of plants with 4 responses	2
	Number of plants with 3 responses	17
	Number of plants with 2 responses	11
	Number of plants with 1 response	23
	Average number of employees	544

The sample had few missing data points. Tsikriktsis (2005) suggested researchers to replace the missing values with the mean when the missing values do not demonstrate a systematic pattern. Other researchers have adopted the list-wise deletion approach when the sample size is large. Although the results reported in this paper was based on the Tsikriktsis (2005) approach, the list-wise deletion approach yielded almost identical results. Missing value therefore was judged not to be a problem.

In order to check for non-response bias, this research collected demographic information from 20 randomly selected non-responding plants. A two-sample *t* test on this data showed no evidence of significant non-response bias ($p = 0.34$).

Using multiple raters is more difficult in empirical studies but it can provide "a greater degree of methodological rigor, thus leading to a greater degree of confidence in the findings" (Boyer and Verma, 2000, p. 129). However, to obtain the benefits, researchers must carefully assess the inter-rater reliability measures. The Interclass Correlation (ICC) measures for the SPS and DPM factors were both greater than the suggested 0.6.

4.3.4 Measures

SPS, DPM and BSI were measured using the instrument developed by Zhang et al. (2006a). The measurement instrument was created and refined through a rigorous process similar to that of Flynn, Schroeder, and Sakakibara (1994). All ten items representing the three constructs in the measurement instrument used the same 7-point Likert scale (1=Disagree strongly, 2=Disagree, 3=Disagree somewhat, 4=Neutral, 5=Agree somewhat, 6=Agree, 7=Agree strongly, N=No response). Ahire et al. (1996) argue that the 7-point scale is better than a 5-point scale because of its capability to capture more variation. The large scale empirical test using the Confirmatory Factor Analysis (CFA) method supported the validity of the instrument (Zhang et al., 2006a). Table 4-2 shows the ten items for the SPS, DPM and BSI constructs and the descriptive statistics.

The dependent variable for this study was the Supplier Operating Performance (SOP) factor. Operating performance is typically measured in five dimensions: quality, cycle time, delivery, cost, and flexibility (Benson, Cunningham, and Leachman, 1995; Ferdows and De Meyer, 1990). The scales used by Ahire et al. (1996) were adapted for this study. Their scale was anchored on the worst companies in the industry, essentially a reversed scale. This research asked the HTI buyers to give their evaluation of supplier performance on all five performance dimensions compared to the "best in the industry" (see Table 4-2).

Multiple responses from the same plant were first averaged to obtain one observation for that plant. Then the validity of the measurement instrument was examined statistically with SPSS. Principal Components Analysis (PCA) with the Varimax rotation was performed to determine scale unidimensionality. Cronbach's alpha for all three scales was examined.

SPS consists of three items. Cronbach's alpha for the SPS scale was 0.694, clearly exceeding the minimum acceptable standard of 0.6 suggested by Nunnally and Bernstein (1994). PCA found that all three SPS items loaded onto a single factor. The eigenvalue was 1.893, higher than the minimum acceptable level of 1.0. The SPS factor explained 63.1% of the variation. The factor loadings for all the items ranged from 0.604 to 0.898, all above the acceptable lower bound of 0.4 (Carmines and Zeller, 1979).

Table 4-2
Measurement instrument

Construct	Item	*N*	Mean	S.D.
Strategic Project Selection (SPS)	Process improvement projects are generated based on our strategy.	53	5.67	0.93
	We prioritize new process improvement projects based on our strategy.	53	5.80	0.88
	Process improvement project selection is driven by our customers' needs.	53	5.74	0.93
Disciplined Project Management (DPM)	Our process improvement projects are led by full-time process improvement experts.	53	4.98	1.65
	Our leadership holds process improvement project team leaders accountable for project results.	52	5.51	1.13
	Our projects use a standard process improvement methodology and language.	53	5.37	1.18
	Our projects have a charter that defines the metrics, goals, deliverables, scope, and timeline.	52	5.55	1.24
Buyer-driven Supplier Improvement (BSI)	HTI includes us in their production planning activities.	49	4.65	1.58
	HTI has process improvement programs that include us.	47	4.60	1.75
	HTI helps us improve our processes.	49	5.15	1.12
Supplier Operating Performance (SOP)	This supplier has the best internal first pass yield rate in the industry.	42	4.64	1.18
	This supplier's throughput time is the best in the industry.	51	4.35	1.37
	This supplier's delivery performance is the best in the industry.	53	5.04	1.51
	This supplier has the best unit cost in the industry.	53	4.37	1.22
	This supplier has the best ability to quickly adjust production capacity in the industry.	52	4.46	1.26

DPM consists of four items. The DPM scale had a Cronbach's alpha of 0.868, much higher than the minimum value of 0.6. All four items loaded onto a single factor and the loadings ranged from 0.794 to 0.913. The eigenvalue associated with the scale was 2.938. The DPM factor explained 73.4% of the variation.

BSI consists of three items. The BSI scale had a Cronbach's alpha of 0.645, higher than 0.6. All three items loaded onto a single factor and the loadings ranged from 0.725

to 0.826. The eigenvalue associated with the scale was 1.761. The BSI factor explained 58.7% of the variation.

SOP consists of five items. However, factor analysis showed that all five items except for the cost item loaded onto one factor. Therefore, cost was dropped from the factor. The cost item is really the price as seen by the HTI buyers. The suppliers' prices are affected by many different factors such as the plant's total volume, market position vis-à-vis its competitors, product technology, process technology, and many other factors that are likely outside the buyer's ability to interpret accurately (Hendricks and Singhal, 2001). Among the operating performance dimensions, the cost data is confounded by many factors and was eventually excluded from the performance factor. Cronbach's alpha for SOP with four items was 0.689. Items loadings ranged from 0.437 to 0.921. The eigenvalue was 2.108. The factor explained 52.7% of the variation (see Table 4-3).

Table 4-3
The SPS, DPM, BSI and SOP factors

		SPS	DPM	BSI	SOP
Cronbach's Alpha		0.694	0.868	0.645	0.689
Factor loadings					
	Item 1	0.898	0.794	0.725	0.773
	Item 2	0.850	0.869	0.826	0.921
	Item 3	0.604	0.913	0.744	0.685
	Item 4		0.847		0.437
Eigenvalue		1.893	2.938	1.761	2.108
Variation explained		63.1%	73.4%	58.7%	52.7%

Once factor analysis confirmed the validity of all four scales, the factor score for each construct were calculated using regression in SPSS. As a weighted average, the factor score represents the contribution of each item for a factor very well and is recommended for regression analysis (Hair, 1995). The factors scores were used in the subsequent regression analyses.

This study used different informants for the dependent and independent variables to avoid problems that can occur with common method bias. Common method biases occur when the variance is attributable to the measurement method rather than to the constructs that the measures represent (Campbell and Fiske, 1959). It is most likely to occur in survey research when all variables are collected from the same informants. With common method bias, the validity of the conclusions is threatened because it is hard to tell whether the relationships represent the reality or just the respondents' perception (Podsakoff, MacKenzie, Lee, and Podsakoff, 2003). In this study, the dependent variable SOP was evaluated by HTI buyers and the independent variables (SPS, DPM, and BSI) were provided by managers from supplier plants. This eliminates concerns about common method bias and increases the credibility of the results.

The effect of organizational size needs to be controlled in the subsequent regression analyses. Although researchers have different opinions on how size influences performance, almost all of them agree that size is an important control variable for empirical studies. The control variable for this study is the Number of Employees (EMP) as Daft (2000, p. 18) suggested that "because organizations are social systems, size is typically measured by number of employees." The distribution of EMP was highly skewed (as expected), a natural log transformation was therefore applied following Neter, Kutner, Nachtsheim, and Wasserman (1996).

4.4 Method

Ordinary least squares (OLS) regression method was used to analyze the empirical data. Moderated Regression Analysis (MRA) was used to test the moderation hypothesis.

The Baron and Kenny (1986) procedure was followed in testing the mediation model. All assumptions of OLS regression were examined before any conclusions were drawn.

4.4.1 Moderated Regression

In MRA, the moderation effect is supported if an interaction term is statistically significant in a regression equation. An interaction term is the cross product of two or more independent variables. Venkatraman (1989) cautioned researchers that the MRA method should only be used when the research hypothesis was that the outcome is jointly determined by the interaction of the independent variable and moderator. In contrast, if the research hypothesis was that the impact of the independent variable on outcome differs across different levels of the moderator, subgroup analysis is more appropriate. Since the hypothesis is that it is the interaction between BSI and SPS, or BSI and DPM that determines the performance level, MRA is the appropriate method.

4.4.2 Mediation model test method

Mediation model test requires several simultaneous regression analyses. Baron and Kenny (1986) and Judd and Kenny (1981) suggested a general procedure that included four steps. The first step is to present a statistically significant relationship between an independent variable (IV) and a dependent variable (DV). The second step is to show that the IV is significantly correlated with a mediation variable (MV). In the third step the DV will be regressed on both the IV and MV to show that the MV affects the DV. The establishment of a mediation model requires statistically significant coefficient in all three steps.

The final step is to observe whether the coefficient for the IV in the third step is close to zero. If it is close to zero, the MV fully mediates the IV-DV relationship;

otherwise a partial mediation model is supported. It is worth noting that the observation is not made based on statistical significance because trivially small coefficients can be statistically significant with large sample sizes and very large coefficients can be insignificant with small sample sizes (Baron and Kenny, 1986).

The procedure can be used to informally judge whether mediation is occurring or not. A formal assessment involves statistical tests (MacKinnon, Lockwood, Hoffman, West, and Sheets, 2002; MacKinnon, Warsi, and Dwyer, 1995). The most commonly used one is the Sobel (1982) test, which is a z test with two major variants, Aroian and Goodman. The test examines whether the effect reduction of the IV on the DV when the MV is added to the model is statistically different from zero.

The existence of causal links among the three variables is the fundamental requirement of a mediation model. The above procedure can be used to assess model-data fit but not for proving causality among the variables. The alternative reverse causal model must be ruled out before researchers can claim the validity of the mediation model. Reverse causal model refers to the possibility that both the IV and MV are in fact caused by the DV. Reverse causal model is always a threat to a mediation model because if researchers cannot theoretically rule out the possibility, it is impossible to statistically distinguish the two models. In this study, the reverse causal model (SOP → BSI) is not supported by the literature or by logical reasoning so the validity of the model is not threatened.

One important analytical issue with the method is the controlling of the effect of additional variables in the model. Many times a mediation model will have more than three variables. The test of mediation effect follows the same procedure. However, correct estimation of the mediation effect requires appropriate controlling of the effect of the additional variables (Baron and Kenny, 1986).

4.4.3 Multicollinearity

In both moderation and mediation models, multicollinearity is expected. In moderation models, the cross-product term is likely correlated with the original variables. In mediation models, the MV and IV are correlated by definition. Multicollinearity may not change the overall fit of the model but it will enlarge the standard error of the individual coefficients, hence incorrectly showing an important variable to be statistically insignificant (Hair, 1995).

Multicollinearity is present in this study but its negative impact is minimal, as shown by the very low Variation Inflation Factor (VIF) values. VIF values lower than 4 are considered acceptable (Hair, 1995). All the regression analyses in this study had VIF values lower than 2. Correlations among the variables in the moderation models were in fact very low, probably due to the fact that factor scores were used. Factor score were centered on zero and centering variables typically can reduce the level of correlation. In summary, multicollinearity was judged not to be a problem.

4.5 Results and Discussion

4.5.1 Results

The means, standard deviations, and correlations of the variables under consideration are displayed in Table 4-4. The effect of control variable is examined first, followed by the hypotheses in order.

Table 4-4
Descriptive statistics and correlations[a]

	Variable	N^b	Mean	S.D.	1	2	3	4	5
1.	SOP	53	0	1	1.000				
2.	SPS	53	0	1	0.492***	1.000			
3.	DPM	53	0	1	0.407**	0.620***	1.000		
4.	BSI	49	0	1	0.375**	0.495***	0.395**	1.000	
5.	Ln(EMP)	49	5.223	1.357	0.254	0.067	0.282	.112	1.000

[a] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[b] Sample size adjusted for missing data.

Table 4-5 provides the results of the regression analysis. Model 1 gives the regression of the control variable on the performance variable, which is insignificant ($F = 3.236$, $p = 0.078$). This suggests that HTI buyers' evaluation of supplier plant performance was independent of plant size. Model 2 examined the impact of the buyer's BSI effort on supplier performance. The model is significant ($F = 5.163, p = 0.01$) with a positive coefficient for BSI, suggesting that BSI is positively associated with supplier performance. The R^2 is 19.4%. Therefore, hypothesis H1 is supported.

Model 3a, 3b, and 3c examine the three moderation hypotheses. Modal 3a examines the moderation effect of SPS on BSI. Model 3b examines the moderation effect of DPM on BSI. Model 3c examines the simultaneous moderation effect of SPS and DPM on BSI. In all three models, the interaction terms are insignificant. Hypotheses H2a, H2b, and H2c are not supported. This research finds, therefore, that SPS and DPM do not moderate the effect of BSI on performance.

Table 4-5
Regression results

	DV = SOP						DV = SPS	
	Model 1		Model 2		Model 4		Model 5	
	β	*t*	*β*	*t*	*β*	*t*	*β*	*t*
Intercept	-1.017	-1,800	-0.763	-1.494	-0.748	-1.490	-0.050	-0.390
Ln(EMP)	0.188	1.799	0.124	1.301	0.128	1.369		
BSI			0.367	2.773**	0.200	1.415	0.505	3.906
SPS					0.392	2.401*		
DPM					-0.035	-0.212		
R^2	6.4%		19.4%		31.6%		24.5%	
F	3.236		5.163		4.732		15.256	
P	0.078		0.01		0.003		0.000	
N	49		46		46		49	

	DV = SOP					
	Model 3a		Model 3b		Model 3c	
	β	*t*	*β*	*t*	*β*	*t*
Intercept	-0.739	-1.448	-0.760	-1.508	-0.729	-1.431
Ln(EMP)	0.128	1.358	0.119	1.268	0.118	1.244
BSI	0.200	1.403	0.160	1.076	0.146	0.970
SPS	0.388	2.341*	0.383	2.336*	0.367	2.200*
DPM	-0.030	-0.179	-0.012	-0.073	0.015	0.087
SPS × BSI	-0.026	-0.200			-0.100	-0.677
DPM × BSI			0.153	0.872	0.215	1.081
R^2	31.7%		32.9%		33.6%	
F	3.705		3.915		3.295	
P	0.008		0.006		0.01	
N	46		46		46	

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Sobel test: 2.045, $p = 0.041$
Aroian test: 1.998, $p = 0.046$
Goodman test: 2.096, $p = 0.036$

Models 2, 4, 5 together examine the mediation hypothesis. Model 2 first shows that BSI is positively associated with performance. This establishes the basis that there could be an effect to be mediated. Model 5 then shows that BSI and SPS are positively correlated ($F = 15.256, p = 0.000$). Finally, Model 4 shows that the coefficient of BSI is smaller than that of Model 2 when SPS and DPM are added to the model. As described earlier, SPS is added to the model as a mediator, and DPM is added as a control variable. Because SPS was known to mediate the relationship between DPM and supplier performance (Zhang et al., 2006b), DPM must be included in the model so that the correct estimate for SPS can be obtained. The reduced coefficient of BSI informally suggests the existence of mediation effect from SPS. Then the three Sobel tests give the same conclusion, statistically confirmed the mediating role of SPS. Hypothesis H3, therefore, is supported.

4.5.2 Discussion

These empirical results confirm that BSI is an important factor in the effectiveness of process improvement programs. BSI is positively associated with supplier performance. Empirical results further reveal that the relationship between BSI and SPS is best described by a mediation model rather than a moderation model. All three moderation hypotheses are not supported, suggesting that the effect of BSI on performance is not moderated by either SPS, DPM or both. Instead, the mediation hypothesis is supported.

The regression coefficient of BSI in model 4 is smaller than that of Model 2. This size reduction is the key to the establishment of the mediation effect. The coefficient, although smaller, is not close to zero. This suggests that a partial mediation model is more appropriate than a full mediation model. In summary, a strong BSI will lead to both a high level of SPS and a high level of supplier performance, and a high level of SPS will further contribute to supplier performance.

4.5.3 Limitations

The two main limitations of the study are that the empirical data for this study was from supplier plants for one large high-tech firm and that the sample size was not very large. The study, therefore, may not be generalizeable beyond the types of suppliers in our sample. Replication of this study is needed to address the concern. The sample size (N=53 plants) was large enough to find very interesting and statistically significant relationships; however, a larger sample size would provide for more statistical power and also enable the use of more powerful statistical methods such as Structural Equation Modeling (SEM).

4.6 Conclusions

This research focuses on the fit among Process Improvement Program Management (PIPM) factors and the impact of the fit on supplier performance. The study by Zhang et al. (2006b) examined the fit between two internal PIPM factors -- Disciplined Project Management (DPM) and Strategic Project Selection (SPS). This study extends that research to consider an external supply chain factor called Buyer-driven Supplier Improvement (BSI). This research addresses the important research questions of whether BSI impacts supplier performance, and if so, how it impacts supplier performance. Guided by the well-known fit theory, this research develops and tests three hypotheses. The first hypothesis examines the direct impact of BSI on supplier performance. The second and third hypotheses examine the form of the fit between BSI and the two internal PIPM factors: SPS and DPM, and the impact of the fit on supplier performance. The second hypothesis argues for a moderation form of fit and the third one argues for a mediation form of fit, hence they are competing hypotheses.

A large-scale empirical study was then conducted in collaboration with a large high-tech electronics firm that allowed the research team to survey its key suppliers. This study avoided the definitional issues surrounding specific process improvement program practices (e.g., Six Sigma or Lean), and did not ask respondents to identify which process improvement programs that they had implemented. A sample was collected from multiple respondents from 53 plants. The analysis of empirical data found that BSI has a significant positive impact on supplier performance, and more importantly, revealed that the form of external fit is mediation: SPS partially mediates the relationship between BSI and supplier performance.

Both Zhang et al. (2006b) and this research found SPS to be a mediator. SPS mediates the relationship between DPM and supplier performance, SPS also mediates the relationship between BSI effort and supplier performance. SPS thus can be considered the critical path for process improvement program success. SPS' mediating role is a novel insight that is not addressed in both the process improvement and project management literature. Most past studies only considered project selection as a direct factor. This novel insight presents an interesting challenge to both scholars and managers: How can we benefit from this insight to make process improvement programs more successful?

This study contributes to the process improvement literature. Complementary to Zhang et al. (2006b), this study again validated the usefulness of the newly proposed PIPM research perspective (Zhang et al., 2006a). More importantly, this study extends the investigation to the supply chain context in addition to internal program management effort. Specifically, this study addressed the question of how BSI effort impacts supplier performance through process improvement programs. This extension is an important contribution because most studies of process improvement programs focused on an organization's internal issues. Only a few studies addressed issues such as supplier relationship but their focus is always the impact on the focal organization but not the suppliers or customers. There is an urgent need to study the impact of process improvement in the supply chain. This study hence contributes to the further development of process improvement research.

This study also contributes to the SCM literature. First, the SCM literature recognized that buyer-supplier collaboration effort contributes to both buyer and supplier performance (e.g., Carr and Pearson, 1999), but the literature did not provide a clear explanation for the working mechanism. This study focused on an important type of buyer-supplier collaboration: BSI effort. This study uncovered the working mechanism of how BSI impacts supplier performance: partially mediated by SPS. Second, this study shows that the management of SCM practices is critical to supplier performance, if not more important than the practices themselves. The findings in this study call upon researchers to consider including program management factors in future SCM research. Third, this study implies that there exists "best practices" for the management of SCM practices. These "best practices" can be easily shared by firms and contribute to performance improvement in the supply chain.

Finally, this study contributes to the development of a new research area: supply chain process improvement. The integration of both process improvement and supply chain management can yield fruitful research findings. The new area can address the deficiencies related to both disciplines. The process improvement literature has often focused on internal issues, not considering supply chain related issues sufficiently. The SCM literature has concentrated on practices but not the processes of improvement. Research in the new area has the potential to significantly contribute to both the literature and practice.

This study also provides useful guidance for practicing managers. For the managers of a buyer firm, this study shows that BSI effort is an important and effective way to improve supplier performance. This study suggests specific activities buyer firms can adopt such as involving suppliers in the production planning process and helping suppliers improve their processes. For the managers of a supplier plant, this study shows that BSI effort is an important resource for supplier performance improvement. Many times external effort such as BSI can promote organizational changes more effectively than a supplier's internal effort. Suppliers therefore should leverage the buyer's BSI effort as a change agent. It also makes sense for the suppliers to actively approach the buyer firm to request involvement in the buyer's production planning and process improvement activities.

This study can be extended in several directions. First, this research examined the impact of external fit on supplier performance. A natural extension of the study is to examine the impact of the fit on buyer performance. Although it is generally accepted in the literature that better supplier performance will contribute to better buyer performance, a direct empirical examination can provide stronger support to the usefulness of the PIPM research perspective. Second, the measurement instrument by Zhang et al (2006a) was developed for manufacturing plants. It will be interesting to see how the measurement instrument can be adapted for other types of organizations such as service providers. The adapted measurement instrument can then be used to investigate whether the impact of both internal and external fit on performance is different. This study may also be extended to consider other supply chain contextual factors such as information sharing in the supply chain.

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CHAPTER 5
CONCLUSIONS

The purpose of this chapter is to summarize the overall findings from the dissertation research and to discuss the general contributions to the literature and practice. The chapter will also discuss the limitations of the research and suggest several ways to extend the research.

5.1 Summary of findings

This dissertation research proposed studying process improvement programs from the program management perspective. Following the complementary three-essay research approach, the first essay proposed the Process Improvement Program Management (PIPM) research perspective and developed a measurement instrument for three important PIPM constructs -- Strategic Project Selection (SPS), Disciplined Project Management (DPM), and Buyer-driven Supplier Improvement (BSI). The instrument was then validated empirically by data collected from 68 supplier plants.

The second essay empirically examined the effect of the two internal PIPM factors (SPS and DPM) on Supplier Operating Performance (SOP) and the form of fit between SPS and DPM. This study showed that both factors have a significant positive impact on SOP, and the form of fit is mediation: SPS partially mediates the relationship between DPM and SOP.

The third essay then examined the effect of BSI on SOP and the fit between BSI and the two internal PIPM factors (SPS and DPM). Regression analysis showed that BSI significantly impacts SOP and SPS also partially mediates the relationship between BSI and SOP. The three studies together show that the program management can explain a large portion of performance variation and is a valid research perspective.

SPS was found to be a mediator in both empirical studies. SPS thus can be considered as a "critical path" variable for process improvement program success. Both the process improvement and project management literature have not addressed the mediating role of SPS. Most past studies only considered its direct impact on performance.

5.2 Contributions

This dissertation research makes two contributions to the process improvement literature. First, the dissertation research proposed the new PIPM research perspective and validated a measurement instrument for PIPM. The empirical studies then showed that all three PIPM factors (SPS, DPM, and BSI) can significantly impact performance. More importantly, the studies revealed the form of internal fit is mediation.

PIPM, therefore, represents a fruitful new approach for studying process improvement programs. All process improvement programs require program management activities and these activities can be easily shared by different process improvement programs. To a certain degree, this dissertation research shows that there exists program management "best practices" that can be easily shared.

Second, the studies extended process improvement research to the supply chain. This research considers not only an organizations' internal PIPM effort but also an important supply chain contextual factor – Buyer-driven Supplier Improvement (BSI). Specifically, the third essay addressed the question of how the buyer's BSI effort impacts supplier performance through process improvement programs. This is an important contribution because most studies of process improvement programs focused on an organization's internal process improvement efforts. For the few studies that have addressed issues such as supplier relationship, their focus is still the impact of such issues on the focal organization's performance rather than the supplier's performance.

This dissertation research also contributes to the supply chain management (SCM) literature. The SCM literature recognizes that buyer-supplier collaboration effort contributes to both buyer and supplier performance (e.g., Carr & Pearson, 1999), but the literature does not provide a clear explanation for the working mechanism. The third essay addressed the gap by uncovering the working mechanism of how BSI impacts supplier performance through SPS. The findings call upon researchers to consider including program management factors in future SCM research.

This dissertation research contributes to the development of a new research area -- supply chain process improvement. The integration of both process improvement and supply chain management can yield fruitful research findings. The new area can address the deficiencies related to both disciplines. The process improvement literature has concentrated on internal process improvement issues and has largely ignored improvement across the supply chain. The SCM literature has concentrated on materials flow issues in the supply chain and has largely ignored process improvement issues. Research in this new area has the potential to significantly contribute to the literature and practice in both the process improvement and SCM disciplines.

Finally, this dissertation research also provides useful guidance for practicing managers. For the managers of a buyer firm, this study shows that the buyer's BSI effort is an important and effective way to improve supplier performance. This study suggests specific activities that buyer firms can adopt such as involving suppliers in the production planning process and in helping suppliers improve their processes.

For the managers of a supplier plant, this study shows that the buyer's BSI effort is an important resource for supplier performance improvement. Many times external effort such as a buyer's BSI effort can promote organizational changes more effectively than a supplier's internal effort. Suppliers therefore should leverage the buyer's BSI effort as a change agent. It also makes sense for the suppliers to actively approach the buyer firm to request involvement in the buyer's production planning and process improvement activities.

Inside the supplier plant, managers should focus on creating a disciplined project management environment. The disciplined culture will then drive improvement into their organization's process improvement project selection effort, and eventually lead to performance.

In summary, this dissertation research has achieved the goal of gaining novel insights about PIPM. The validated plant-level measurement instrument can be used in future empirical studies. The insights will inform future theory development. The insights will also provide useful guidance for practicing managers on how to manage their process improvement programs.

5.3 Limitations

Two limitations of the dissertation research need to be recognized. First, the empirical data for all three studies was collected from supplier plants of the same electronics manufacturer. This dissertation research, therefore, is subject to the challenge that the sample may contain common variation due to the common buyer firm. Although the diversified supplier base suggests that this is probably not the case and the results should be fairly generalizeable across industries, a more generic sample can effectively address the concern of generalizeability.

Second, the sample size for the empirical studies is decent but it is desirable to have a larger sample size. A larger sample size means stronger statistical power in the analysis. A larger sample size also enables researchers to choose other more powerful analysis methods such as structural equation modeling (SEM).

5.4 Future research

This dissertation research can be extended in several ways. First, researchers can consider replicating the study with a more generic sample. This can address the limitation of the current research. A sample of randomly chosen manufacturing plants not supplying the same buyer firm can increase the generalizeability of the conclusions. Researchers should also try to get a larger sample size for the replication studies.

Second, this dissertation research can be extended to consider PIPM for distribution and service firms. The current measurement instrument was developed for manufacturing plants and the sample contains only manufacturing plants. However, process improvement programs are never limited to manufacturing plants. In fact, many distribution and service organizations have adopted process improvement programs and have achieved significant performance improvement. Service industries employ the vast majority of work force in Western countries and contribute to more than 80% of the economy. Service operations have their distinct characteristics and these characteristics may influence how process improvement programs should be managed. In addition, performance measures for service operations are different from manufacturing

(Parasuraman, Zeithaml, & Berry, 1985). Future research can consider replicating the current studies in the service setting. Researchers need to first adapt the current plant-level PIPM measurement instrument for service firms, and then use it to empirically examine the fit relationships.

Third, the current studies used supplier operating performance as the dependent variable. However, operating performance is not the only measurement for organizational effectiveness. Future studies can consider examining the impact of fit relationships on other measures such as business performance and competitiveness.

Finally, researchers can consider conducting longitudinal studies. The current studies are cross-sectional in nature. Cross-sectional studies can effectively establish correlations among variables but can hardly prove cause-effect relationships. Longitudinal studies can effectively address the concern.

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