Discovering process management:
One of the least understood concepts in Operations Management

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Dedication

This dissertation is dedicated to my parents,

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Abstract

Organizations increasingly adopt process management practices to remain competitive. Much of the practitioner literature touts the benefits of process management and its impact on operational performance. However, empirical evidence in academic literature is mixed, and some researchers and practitioners question the positive impact of process management on innovation performance. These conflicts deserve further investigation.

In most extant literature on process management, organizational context has not been taken into consideration. The goal of this dissertation is to examine process management and the contextual factors that influence its relationship with performance. This dissertation is organized in three complementary essays that focus on exploring the paradoxes associated with process management and the relationships with internal and external organizational contextual variables. A multi-industry, multi-country data set, collected as part of Round 3 of the High Performance Manufacturing study, is used to test the frameworks developed in each essay.

Process management is a core concept in operations management, but past research has used a number of different and incomplete measures of process management. A part of the paradox arising from research on process management can be attributed to these vague conceptual definitions and inconsistent measures. The first essay of this work examines an alternate, more complete perspective on measuring process management. I propose that process management consists of three distinct elements: process design, process control, and process improvement. Using a scale

development methodology, reliable and valid measurement scales are obtained for all three dimensions.

The second essay examines an aspect of the internal organization context. Companies often overlook the need to create a supportive culture for process management practices. This study presents a theoretical model to examine the relationship between organizational culture, process management, and operational performance using the perspective of process management from the first essay. Organizational culture is operationalized using the four cultural quadrants of the Competing Values Framework. The model is then tested using structural equation modeling. The results indicate that there are different enabling cultural dimensions for each dimension of process management and that process design is the only aspect of process management that differentiates high performing plants on multiple dimensions of competitive plant performance.

The third essay investigates the role of the external environment on the effectiveness of process management. The conceptual model developed in this essay is based on contingency theory. Using organizational learning literature, the three dimensions of process management are linked to innovation and efficiency performance. Additionally, I propose in the final essay that the degree of competitive intensity experienced by the plant moderates the relationships between process management and innovation and efficiency performance. The findings of this study are mixed. The influence of process design on performance is not dependent on competitive intensity; however, the impact of process improvement and process control on performance are in some instances moderated by competitive intensity.

Overall, empirically defining and measuring process management as three related constructs (process design, process control, and process improvement) provides new insights into its effect on performance. Additionally, examining internal and external organizational environments helps resolve conflicts associated with process management. This dissertation confirms that the organizational context must be considered when studying the effectiveness of process management.

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Chapter 1

Introduction

1.1 Motivation

Many corporations today are becoming more process-focused. Companies like Motorola, 3M, GE, and Toyota have become synonymous with successful Six Sigma and Lean Manufacturing programs that focus on reducing variance and eliminating waste in various types of business processes. These management initiatives compel organizations to take a hard look at their organizational processes. Like popular business process initiatives in the past, such as Total Quality Management and Business Process Reengineering, these recent initiatives have enabled sustained performance for many companies and have again brought attention to the practical importance of process management.

Despite the benefits that some companies have received from process management, some academic research and practitioner literature has raised concerns over the limits of process management (Benner and Tushman, 2002; Sterman et al., 1997; White, 2005) and the difficulty in implementing such initiatives in various environments (Benner and Tushman, 2003). In light of this apprehension toward process management, it behooves researchers to reexamine this phenomenon in the current business environment. Additionally, it has been suggested that OM researchers conduct more studies on process management, not just operations management (Silver, 2004) and that paradoxes deserve further investigation to build and extend theory in OM (Handfield and Melnyk, 1998). In an effort to further knowledge in this area, this dissertation addresses the implementation and outcome conflicts associated with process management.

I assert that much of the confusion associated with the effectiveness of process management may be resolved by examining the internal and external organizational contexts. Many of the previous studies on process management did not take into account the organizational context. The internal organizational environment and the external market environment can affect components of quality management (Benson et al., 1991). More studies to empirically investigate the fit between context and process management practices are needed (Nair, 2006).

1.2 Research objectives

The goal of this dissertation is to investigate the internal and external organizational contexts that impact process management and its relationship with various types of performance. To begin, process management must be defined; this is the first dissertation objective. The second objective is to examine the relationship between the internal environment of organizational culture, process management, and performance. The third objective is to investigate the role of the external competitive environment and its influence on the relationship between process management and performance.

This dissertation is organized around three complementary essays addressing each objective. Figure 1-1 illustrates the conceptual framework of the dissertation and the linkage between the essays. Definition and measurement of process management is explored in the first essay. The second essay takes an internal perspective, looking at the tensions associated with implementing process management using an organizational culture perspective. The third essay investigates the relationship between process management and innovation and efficiency and the moderating role of environmental dynamism. A brief summary of each essay is outlined in the following section.

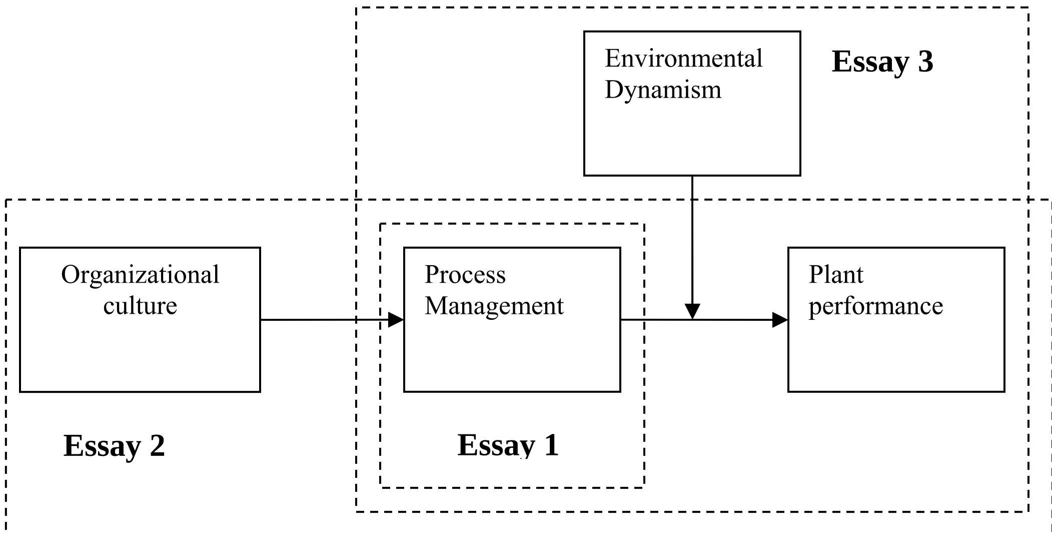

Figure 1-1: Illustration of conceptual framework for dissertation

Many researchers have found mixed results when examining process management and its relationship to operational and business performance. To gain a better understanding of these varied studies, the first essay, "Definition and measurement of the elements of process management," examines the conceptual definitions and measurements of process management used in previous studies. The central premise is that a major reason for conflicting results is the inconsistency in process management definition and measurement. Good measures are based upon good conceptual definitions, and there is a need to develop good measures throughout OM (Wacker, 2004; Gatignon et al., 2002; O'Leary-Kelly and Vokurka, 1998). So, the first essay addresses how to define and measure process management.

I propose that process management consists of three distinct individual elements: process design, process control, and process improvement. These constructs should be measured separately in order to gain a complete understanding of process management. The objectives of this essay are to define the elements of process management and develop and validate a measurement instrument for these constructs using a comprehensive scale development procedure. Subject matter experts are used to assess content validity. For empirical development and validation, the data are split into two separate samples. A smaller sample is used to conduct exploratory factor analysis and refine the scales, while the larger sample is used to validate the measurement instrument utilizing confirmatory factor analysis and to assess reliability and validity. The dissertation develops a reliable and valid measurement instrument for each dimension of process management. Process design, process control, and process improvement become the central constructs for the remaining two essays.

The second essay, "Pulled in all directions: An empirical examination of the competing values associated with process management," examines the internal organizational tensions related to the elements of process management. Using the competing values framework (Quinn and Rohrbaugh, 1983), the relationship between organizational culture and process management is examined. The central research questions are "How do the elements of process management relate to organizational culture?" and "How does the fit between these elements impact plant performance?" Fit is viewed as process management mediating the link between organizational culture and performance.

As proposed in the second essay, process design requires that an organization is flexible in its ability to develop new processes and that the organization is externally focused, ensuring that new processes are meeting the needs of customers. Process improvement also requires that an organization have the flexibility to change existing processes and both an internal and external perspective when enhancing a process. Process control centers on maintaining the stability of existing processes. However, when controlling processes, an organization must balance the internal perspective of regulating processes and activities with the external perspective of ensuring efficiency and meeting customer requirements consistently. The assertion is that the tensions between stability and flexibility and internal and external focus make process management difficult to execute. The findings support the idea that each dimension of process management is associated with a specific set of cultural values and that process design is the key component to achieving high performance.

The third essay is titled "The impact of process management on innovation and efficiency performance: the moderating effect of competitive intensity." This essay examines the external conditions of the environment. There is some evidence that process management does not lead to competitive operational performance (Samson and Terziovski, 1999). Furthermore, some researchers argue that process management actually hampers a firm's ability to innovate (Benner and Tushman, 2002). However, other researchers argue that the effectiveness of process management may be dependent on the fit with the external environment (Sutcliffe et al., 2000). Environmental dynamism is a concept that can be used to describe the rate of change and unpredictability in the environment (Dess and Beard, 1984). In dynamic environments, organizations have to change process and technologies to remain competitive (Donaldson, 2001); thus, this is an important concept to discuss in relation to process management.

One aspect of dynamism is the degree of competitive intensity (Auh and Menguc, 2005). This essay specifically addresses how process management is related to innovation and efficiency performance and how competitive intensity moderates those relationships. From the organizational learning literature, the components of process management are discussed in terms of first order and second order learning (Fiol and Lyles, 1985; Adler and Clark, 1991). All three dimensions of process management are proposed to positively influence efficiency performance through both learning mechanisms. Higher levels of learning, though, are needed for innovation (Tushman and Anderson, 1986; Adler and Clark, 1991), so process improvement and process design are hypothesized as positive impacts on innovation performance, whereas process control will have negative relationship with innovation. Contingency theory is used to show how competitive pressures can moderate these relationships. Using multiple linear regression, the results indicate that the impact of process design on performance is not dependent on competitive intensity, though competitive intensity does moderate some of the relationships between process control and improvement with performance.

1.3 Methodology

All of these studies are focused on examining process management within a manufacturing setting. Other operational settings like healthcare are beginning to utilize process management programs such as Lean and Six Sigma, but process management is well established in manufacturing operations. These studies are conducted at the plant level, where knowledgeable personnel who attend to the processes could serve as respondents.

The data used in this dissertation were obtained as part of the High Performance Manufacturing (HPM) study, Round 3. The HPM project collects information on manufacturing plants within the electronics, machinery, and transportation parts supply industries (Schroeder and Flynn, 2001). This is a global study, and the data for this round come from Germany, Finland, Italy, Austria, United States, Korea, Sweden, and Japan.

Plants were selected from a variety of different sources, and only one plant per company was used. Persons from the research team contacted individual plant managers to confirm their participation before proceeding with data collection. Once their agreement was received, a packet of 21 questionnaires was sent to the plant. The target respondents included direct laborers, supervisors, quality managers, human resources managers, new product development managers, inventory managers, information systems managers, production control managers, process engineers, plant accountants, plant superintendents, and plant managers.

The response rate for Round 3 was 65%. A total of 238 plants are included in the data set. Respondents provided information on a variety of manufacturing practices, operational performance, internal organizational characteristics, and external market conditions. Plants that did not respond often stated that there was not enough time to complete the surveys. For the plants that completed the survey, the plant manager received a profile of the plant's responses plus an industry comparison report.

Empirical research methods are employed in this dissertation using multiple data analytic techniques (Flynn et al., 1990). The first essay uses exploratory and confirmatory factor analysis to develop and test each measurement scale. In the second essay, structural equation modeling is used to test the hypothesized model. The method of analysis for the third essay is multiple linear regression and simple slope analysis.

1.4 Organization of the dissertation

The remainder of the dissertation is organized in the following manner. Chapter 2 is the first essay. The definition of process management is developed, and the measurement instrument is constructed and validated for use in the next two essays. Chapters 3 and 4 represent the second and third essays, respectively. This dissertation concludes with Chapter 5, which notes the overall academic contribution and practical implication of this research, as well as its limitations and directions for future research.

Chapter 2

Defining and measuring the elements of process management

2.1 Introduction

The transformation process of converting inputs into outputs is a critical concept in operations management. The ability to manage and integrate these processes is core to any business (Silver, 2004). The surge of initiatives like Business Process Re-engineering, Six Sigma, and Lean has returned attention to the practical importance of process management and its impact on performance and customer satisfaction. Much of the practitioner literature touts the benefits of process management, yet, in academic literature, the empirical evidence on process management is mixed. Some researchers argue that process management positively impacts some aspects of performance (Ahire and Dreyfus, 2000; Choi and Eboch, 1998), while others disagree about the short and long term effects of process management on various indicators of performance (Sterman et al., 1997; Samson and Terziovski, 1999; Benner and Tushman, 2002).

Some of this inconsistency can be attributed to vague conceptual definitions and inconsistent measures of process management. Good conceptual definitions are the driving force behind good measures (Wacker, 2004). Unfortunately, in academic research process management has not been clearly defined. Therefore, measurement scales vary widely across studies. Consistency between definition and measurement has been neglected, and the conceptual confusion between process management definition and measures needs clarifying "The ability to correctly identify significant relationships among variables depends on our ability to adequately measure the variables" (O'Leary-Kelly and Vokurka, 1998). The lack of good, clean measures and the variety of measures make it difficult to draw confident conclusions about the relationship between process management and other organizational variables.

Handfield and Melnyk (1998) point out that we should explore paradoxes in order to build better theory. The authors also note that many OM concepts do not have specific measures, therefore conceptual definitions and coherent measures have to be developed. Gatignon et al. (2002) state, "an important impediment to theoretical and empirical advance is confusion on concepts, measures, and units of analysis." Recent research has started to resolve these misunderstandings in concepts such as Lean (Shah and Ward, 2007), supply chain management practices (Li et al., 2005), innovation (Gatignon et al., 2002), and just-in-time purchasing (Kaynak and Hartley, 2006). The purpose of this study is to do the same for the concept of process management.

The first objective of this study is to develop a conceptually grounded definition for process management. We propose that process management cannot be measured as a single construct, but instead should be measured on multiple dimensions. Process management is broken down into the three elements: process design, process control, and process improvement. The second objective is to construct and validate a measurement instrument for these three dimensions. Utilizing a multi-step, rigorous empirical method, measures for the dimensions of process management are operationalized and validated. Finally, we examine whether these constructs reflect a higher order dimension of process management.

This essay contributes to the current literature by presenting a comprehensive definition and measurement of process management. Also, with this measurement instrument, the assessment of process management in an organization is not influenced by specific practices or programs (i.e. Lean, Six Sigma, TQM, etc.). Furthermore, separating process management into multiple elements will open the door to future research that will yield new insights about the phenomena of process management.

The remainder of the essay is organized in the following manner. The next section describes the previous literature on process management, paying particular attention to conceptual definitions and measurements. In section 3, a conceptual framework and definitions for process management and its components are developed. This is followed by measurement development and validation in sections 4 and 5, respectively. The essay concludes with implications, limitations, and future research.

2.2 Literature review

A literature review of process management studies reveals a number of different definitions, measures, and methods for studying process management. The review of the literature is organized by the method of measurement, depending on if process management was a measured as a set of multiple practices or as a single dimension construct. It is also noted whether process management was examined as part of a larger total quality management framework or as the main subject of the study. A summary of the extant literature is found in Table 2-1.

Table 2-1: Previous definitions and measures of process management

Author(s)	Objective of study	Definition of Process Management used	Measure of Process Management
TQM focused studies, single construct for process management			
Anderson et al. (1995) Rungtusanatham et al. (1998, 2005)	Does level of use and pattern of use of TQM differ across countries	The set of methodological and behavioral practices emphasizing the management of process, or means of action, rather than results	3 item scale focused on statistical quality control
Powell (1995)	Investigate the relationship between TQM factors and firm level performance.	Process Improvement – reduce waste and cycle times in all areas through cross-departmental process analysis	5 item scale focused on programs that reduce waste
Kaynak (2003)	Examine the relationship between TQM practices and firm performance	Preventative approach to quality improvement	4 item scale covering inspection, schedule stability, process automation, fool-proofing
Flynn et al. (1995)	Exploratory analysis of quality infrastructure practices, core quality practices, and quality performance (path analysis and regression)	Process flow management is tools and techniques used to reduce process flow variance	14 item scale capturing preventative maintenance, fool-proofing process, Cleanliness/organization, Management presence, Scheduled downtime, Ability to stop process
Samson and Terzvioski (1999)	Investigate the relationship between TQM practices and operational performance	Design and introduction of products and services integrating supply, production, and delivery	5 item scale spanning supplier relations, quality measures, and SOPs.
Choi and Eboch (1998)	Examine the relationships between TQM practices, customer satisfaction, and plant quality performance	Process quality is the monitoring and improving of work processes by reducing variation	5 item scale focused in maintenance, problems-solving activities, and usage of quality data

Table 2-1 cont'd: Previous definitions and measures of process management

Author(s)	Objective of study	Definition of Process Management used	Measure of Process Management
Process management studies, single construct for process management			
Benner and Tushman (2002)	Examine the effect of process management on technology innovation	"Techniques focus on improving an organization's activities in a rationalized system of end-to-end processes"	# of ISO 9000 certifications (exploitation and exploration measured as patent citations to precious patents)
Ahire and Dreyfus (2000)	Examine the effects of design and process management on quality performance	Tracking and improvement of manufacturing process quality	5 item scale focused on rework, corrective action, process improvement, and SPC
TQM focused studies, multiple practices/second order construct for process management			
Meyer and Collier (2001)	Empirical examination of Baldrige framework for Health Care sector	How key processes are designed and delivered	6 practices ▪ Design and delivery of health care services ▪ Patient support services ▪ Community health services ▪ Business operations management ▪ Supplier performance management
Process management focused studies, multiple practices/second order construct for process management			
Sousa and Voss (2001)	Case study investigating the contingent effect of manufacturing strategy on the use quality practices	Tools used to manage process quality	5 constructs of PM practices • Formalized new product introduction process • Zero defects • Changeover inspection • Real time in-process feedback • In-process and overall off-line feedback
Ittner and Larcker (1997)	Exploratory study Examining the impact of process management techniques on financial performance ROA and ROS	Techniques used to manage a process. A process is a set of activities that taken together produce a result of value to a customer	5 constructs of PM practices • Process focus • Human resource practices • Information Utilization • Customer/supplier relations • Organizational commitment

2.2.1 *Process management as a single dimension construct*

A number of research studies define and operationalize process management as a single construct measured by multiple measurement items. This is most often found in articles that study process management as part of a larger TQM framework. For example, Anderson et al. (1995) and Rungtusanatham et al. (1998, 2005) defined process management as a "set of methodological and behavioral practices," emphasizing the management and improvement of processes that produce goods and services. The authors measured process management as a three-item scale focused on statistical quality control. In the development of measurement scales for TQM constructs, Flynn et al. (1995) describe process management as "tools and techniques used to reduce process flow variance" and develop a 14-item scale to measure process management, capturing many aspects such as preventative maintenance, fool-proofing, scheduled downtime. Others use shorter measurement scales drawing from similar items and definitions. Kaynak (2003) describes process management as taking a preventative approach toward quality improvement and uses a 4-item scale that covers inspection, schedule stability, process automation, and fool-proofing. Samson and Terziovski (1999) use a 5-item scale spanning supplier relations, quality measures, and standard operating procedures. Similarly, a 5-item scale is used in a study by Choi and Eboch (1998) which contains information on aspects such as maintenance and usage of data.

Other studies that used single dimension constructs or objective measures were primarily focused on solely studying the process management phenomena. For example, Ahire and Dreyfus (2000) define process management as monitoring and improving manufacturing processes. They created a five-item process management scale focused on rework, corrective action, process improvement, and statistical process control. According to Benner and Tushman (2002), process management is a set of "techniques focus(ed) on improving an organization's activities in a rationalized system of end-to-end processes." But, in their study, the number of ISO 9000 certifications was used as a measure of process management (Benner and Tushman, 2002). At the time the data were collected for Benner and Tushman (2002), firms were using an older version of ISO 9000 which measured conformance to standards.

2.2.2 Process management as multiple practices

An alternate measurement approach found in the literature defined process management as a set of practices. It measured the concept as a collection of separate operational practices using multiple scales or as a second order factor. This was found in two TQM focused studies in which the authors defined process management based on the Malcolm Baldridge National Quality Award. Process management was then measured as a second order latent construct formed by multiple manufacturing practices (Meyer and Collier, 2001; Wilson and Collier, 2000).

Ittner and Larcker (1997) described process management as techniques used to manage a process. The authors used a set of manufacturing practices based on human resource practices, customer/supplier integration practices, information utilization, organizational commitment, and process focus. Likewise, Sousa and Voss (2001) used a similar definition. The process management practices measured in their study consist of various practices like process feedback, zero defects, and formalized new product introduction.

2.2.3 *Shortcomings of previous definitions and measures*

A few insights are drawn from the literature review. There appears to be a gap in how researchers defined and measured process management among the studies. Furthermore, process management has been measured in a number of different ways with little or no agreement across studies.

The underlying theme of previous definitions of process management is the management and improvement of processes. However, this premise is confusing for several reasons. To start, in accordance with Wacker (2004), "a 'good' definition is defined as: a concise, clear verbal expression of a unique concept that can be used for strict empirical testing." Using the term "management" in the definition further muddies the concept. Additionally, according to Teas and Palan (1997), the name of the concept being defined should not be contained in the conceptual definition. It is incorrect to define process management as "practices emphasizing the management of processes" (Anderson et al., 1995; Rungtusanatham et al., 1998). Clearly, a less ambiguous definition is needed.

Viewing process management as a first order, multi-item construct is a concern. Using a single scale to measure process management limits the ability to completely measure all aspects of process management. The scale may meet construct validity and reliability criteria, but that is based on a restricted definition of process management. If the conceptual definition is compromised, then the measures are too, regardless of whether or not they meet statistical criteria (Teas and Palan, 1997; Nunnally and Bernstein, 1994; Wacker, 2004).

Some of the previous definitions and measures are built on a traditional view of process management based on controlling and/or improving a process once it is implemented, thus limiting the conceptual definition of process management (Choi and Eboch, 1998; Ahire and Dreyfus, 2000). Quietly missing from previous definitions are the ideas of process development and implementation which are often the phases where customer requirements are incorporated into the process.

The terms “tools and techniques” are used in several definitions (Benner and Tushman, 2002; Ittner and Larcker, 1997; Sousa and Voss, 2001). Tools, techniques, and methods are ways to perform a task (Matson and Prusak, 2003). This is problematic for two reasons. First, this approach lacks discriminant validity because some of these tools and techniques (e.g., customer/supplier integration) are also associated with other operations management constructs, such as supply chain management (Li et al., 2005; Rosenzweig et al., 2003; Frohlich and Westbrook, 2001). Subsequently, using this measurement approach compromises the theoretical and statistical assurance of studying one specific operations management concept. Second, process management is a larger concept that firms execute, rather than the tools they use to execute it. For example, many firms use Six Sigma as a method or set of tools for process management. However, if the firm has not implemented a Six Sigma program, the firm can still carry out process management using another set of tools and techniques, such as Lean practices.

Conceptualizing process management as "tools and techniques" forces researchers to identify and measure a variety of methods of approaching a task. It also requires that some presumption is made about the relationship between the amount of tools or techniques used and process management. For these reasons, the conceptual definition of process management must define "what" firms do as opposed to "how" firms do it. This is discussed further in the following section.

The lack of consistency within and among studies inhibits the ability to draw conclusions about process management. The next section clarifies conceptual definitions and operationalizes measures of process management.

2.3 Defining process management

2.3.1 Process management

A process is defined as the organization of work activities that transform inputs (people, equipment, materials, facilities, information, etc.) into a product or service (Pall, 1987). In practice, there are multiple aspects to managing a process including planning and defining the process, process implementation, and controlling and optimizing the process (Hammer, 2002). Juran and Godfrey (1999) emphasized that the Juran trilogy of planning, improvement, and control applied to the process level and it is the combination of these three components that make up process management. Some other researchers have acknowledged that there are multiple components to process management. Silver (2004) identified them as design, control, improvement, and redesign, while Benner and Tushman (2003) described the components as mapping, improvement, and control.

These conceptualizations are similar to the Evans and Lindsay (2005) components of design, control, and improvement. Table 2-2 summarizes these components of process management.

Table 2-2: Summary of elements of process management

	Elements of Process Management					
	Plan	Define or Map	Implement	Design	Improve or Optimize	Control
Hammer, 2002		X	X		X	X
Juran, 1999	X			X	X	X
Silver, 2004				X	X	X
Benner and Tushman, 2003		X			X	X
Evans and Lindsay, 2002				X	X	X

Consistent across frameworks is the improvement and control of processes. Additionally, each one captures some aspect of process design. It is, then, these three components—process design, process control, and process improvement—that constitute process management. The following definition of process management is used:

Definition: *Process management is the design, control, and improvement of a system of organized work activities that result in a product or service.*

A good, formal conceptual definition, as defined by Wacker (2004), is concise, parsimonious, clear, consistent with the field, and unique. This definition of process management is consistent with previous academic literature on process management

(Evans and Lindsay, 2005; Juran and Godfrey 1999) and is simply stated with unambiguous terms.

This definition also distinguishes process management from operations management, which is a functional management area concerned with quality, processes, inventory, and capacity (Schroeder, 2007). Process management is just one aspect of operations management and can occur within any functional area because it can be applied to a variety of business processes (Hammer, 1990). Many organizations design, control, and improve human resource processes, accounting processes, and other critical business processes.

Process management also differs from and is an aspect of quality management. Previous TQM studies consider process management as one element of a quality program. Additionally, the Baldrige framework is a well established example of a comprehensive quality management and performance improvement program. Within it, process management is one element of the quality management system.

2.3.2 Process design

Process management begins with process design and is a key element that cannot be separated from the others (Juran and Godfrey, 1999; Evans and Lindsay, 2005; Anderson et al., 1994). Juran and Godfrey (1999) noted that, to understand process quality, managers have to understand how processes are planned. Organizations select the process, define the process boundaries, determine customer needs, and design and implement the process so that output meets customer requirements. As the business environment changes, organizations must reassess their processes as the assumptions and foundation on which the processes were designed may no longer be valid, making new processes needed (Hammer and Champy, 1993). Additionally, a part of process design is identifying gaps in the process and opportunities for errors in an effort to guard against them. Deming (1986) stressed that errors occur in the process, not with people, so quality must be designed into the process. The objective of process design is to be proactive in the planning and implementation of processes to prevent defects which should result in a quality product (Evans and Lindsay, 2005). When developing new processes, minimizing variation may not always be the primary goal. Experimentation may be used to widen variation of process specifications and steps in order to obtain the process that best meets customers' needs. Thus, process design is defined as follows:

> ***Definition:*** *Process design is developing a new system of organized work activities with the aim of meeting customer requirements and/or enhancing performance.*

2.3.3 Process control

Process control is a mature concept in operations management and, of the three elements, is the most widely studied. All processes have some inherent variation in the performance of tasks and product or service outcomes (Deming, 1986). As a result, organizations put multiple controls in place to monitor this variation. Process variation can have a significant effect on the degree of consistency of product quality and output ,and many types of controls can be put in place (Juran and Godfrey, 1999). Standard operating procedures (SOP) and protocols are used to standardize how work is performed throughout an organization. Methods and mechanisms are implemented to ensure that those SOPs are followed and that work is performed consistently. Tools such as statistical process control are also used to ensure process control. Additionally, process feedback is a critical component in ensuring consistent production and a key aspect of process control (Flynn et al., 1995). Process control is an imperative aspect of process management because before improving a process, the process must be stable with minimal variation (Evans and Lindsay, 2005). So, process control is defined as follows:

Definition: *Process control is monitoring conditions of a system of organized work activities to maintain stability and consistent performance.*

2.3.4 Process improvement

The final element of process management is process improvement. With the rise of continuous improvement, researchers noted that organizations must not only maintain processes, but also focus on continually improving processes (Flynn et al., 1995). In order to effectively compete over time, firms must improve their operational processes to remain competitive (Juran and Godfrey, 1999). There are several triggers of process improvement such as large variation for existing process and products, product quality problems, and changes in customer demand. However, organizations that are skilled in process improvement do not take a reactive approach. Skillful process improvement emphasizes a proactive approach toward operational improvement (Evans and Lindsay, 2005). Fundamentally, this includes having "the ability to creatively solve problems as well as to identify and take advantage of opportunities for improvement" (Silver, 2004). Better business processes are born from employee suggestions, customer feedback, and team collaboration. Whether the change is major or minor, organizations will at some point have to improve their business processes while ensuring that they still meet customer needs (Hammer and Champy, 1993). Thus, process improvement is defined hereafter as the following:

Definition: *Process improvement is changing an existing system of organized work activities with the aim of meeting customer requirements and/or enhancing performance.*

It is important to address the philosophical and practical orientations of process management that have added to the ambiguity of previous literature. Shah and Ward (2007) highlight this issue with regard to lean manufacturing, and a similar argument holds for process management. The difference between the underlying components of process management and a process management system are shown in Figure 2-1. There are a variety of process management systems that utilize different tools and practices that organizations use to execute process design, process control, and process improvement. For example, Six Sigma is comprised of tools and methods which focus on a structured approach to process improvement and control (Linderman et al., 2003). Design for Six Sigma is also a structured method, but applied to the design and implementation of business processes and products (Creveling et al., 2003). Lean is a set of practices which improve processes by reducing waste and non-value added activities (Treville and Antonoakis, 2006; Shah and Ward, 2007). Other practices, such as statistical process control and ISO 9000, help to maintain consistency of process activities and output and help control processes. Practices and tools are used to implement the three elements of process management. The measurement instrument created in this study is aimed at obtaining information on underlying aspects of process management regardless of the tools and practices used to achieve process design, control, and improvement.

Process management elements (underlying aspects)	Design	Control	Improve
Process management Systems/practices	Design For Six sigma		
	Taguchi Methods		
	Business Process Reegineering		
		SPC	
		Six Sigma (DMAIC)	
		Lean	
			Kaizen
	ISO 9000:2000		
	Baldrige		

Figure 2-1: Relationship between Process Management conceptual definition and process management tools/practices

2.4 Measurement development

2.4.1 Data

Data for scale development and validation were collected as part of Round 3 of the High Performance Manufacturing (HPM) study. The HPM project is a multinational study of manufacturing practices within the transportation parts suppliers, electronics, and machinery industries (SIC codes 35-37). The plants were randomly selected from sources such as the *Industry Week* Best Plant list, Shingo Award winners, trade magazines, and general industry lists. HPM was designed as a stratified, random sample so that an equal number of plants from each country, industry, and high performing and traditional plants are obtained. A phone call was made to each plant prior to mailing the surveys in order to gain participation. Additionally, at the close of the study, each plant manager received a plant profile that provided information about the plant based on the data collected and a comparison to other plants within the same industry. Using this technique yielded a response rate of 65% resulting in a sample size of 238 plants from Korea, Japan, Germany, the United States, Finland, Italy, Austria, and Sweden. These countries represent much of the industrialized manufacturing in the world.

The unit of analysis for this study is the plant. Although processes occur at multiple levels of the organization and there has been an increase in the application of process management to transaction and service processes, manufacturing plants serve as a more mature setting for studying process management. Additionally, the three industries in this research setting cover a range of market and product characteristics, which increases the opportunity to generalize results. Sample description is shown in Table 2-3.

One concern with survey data is that the data collected may not be truly representative of the sample population (Malhotra and Grover, 1998). Non-response bias in the HPM study was evaluated by comparing early respondents to late respondents, suggesting that late respondents may be more characteristic of non-respondents (Armstrong and Overton, 1977). This same approach was taken in other recent measurement development papers (Kaynak and Hartley, 2006; Narasimhan et al., 2006; Li et al., 2005). A two-sample t-test was conducted and found no significant differences (p>0.05) between early and late respondents based on total number of employees, total sales value of production, and percentage of market share.

Table 2-3: Sample descriptive data of plants by industry and country

	AUT	FIN	GER	ITL	JPN	KOR	SWE	USA	Total	% EFA	% CFA
Electronics	10	14	9	10	10	10	7	9	79	35.7	32.1
Machinery	7	6	13	10	12	10	10	11	79	38.6	31
Transportation Parts Suppliers	4	10	19	7	13	11	7	9	80	25.7	36.9
Total	21	30	41	27	35	31	24	29	238	100	100
% EFA Sample	11.4	8.6	20	14.3	14.3	11.4	8.6	11.4	100		
% CFA Sample	7.8	16.1	16.1	10.1	14.9	13.6	10.7	12.5	100		

2.4.2 Item generation

The scale development and validation process is shown in Figure 2-2. Measurement development started with identifying measurement items that were reflective of the content domain for each construct. Eight subject matter experts consisting of academic researchers and process management practitioners individually judged the content of each item. Each expert was asked to place each item in one of four categories: process design, process control, process improvement, or not applicable. Items that were placed in the same construct by a majority of experts were used in the next analysis step. For the EFA, 31 items were retained: 11 items for process design, 10 for process control, and 10 for process improvement.

Generate definition and measurements

- Examine literature to derive conceptual definitions
- Identify measurement items

Develop measurements

- Assess content validity using subject matter experts
- Refine items using EFA on calibration sample
    - Principal component analysis
    - Check reliability and unidimensionality
    - Modify scale as needed, eliminating one item at a time

Validate measurements

- Conduct CFA on validation sample using structural equation modeling
- Examine overall model fit
- Assess individual construct fit for unidimensionality
- Estimate scale reliability
    - Cronbach α coefficient
    - Coefficient of reliability, ρ_c
- Determine convergent validity
    - Examine parameter estimates and Bentler-Bonnet coefficient
- Determine discriminant validity
    - Examine confidence intervals (± two std. error) for factor correlations
    - Conduct chi-square difference test between constrained and unconstrained model
- Determine criteria related validity
    - Examine correlations with criterion variables

Figure 2-2: Scale development methodology

(Sources: Netemeyer et al., 2003; O'Leary-Kelly and Vokurka, 1998; Nunnally and Bernstein, 1994; Campbell and Fiske, 1959; Flynn et al., 1994).

2.4.3 *Results of exploratory factor analysis*

Each item is measured on a 7-point Likert scale ranging from *strongly disagree* to *strongly agree*. Data were collected from multiple respondents in each plant in order to reduce common respondent bias. The respondents include multiple direct laborers, multiple supervisors, a quality manager, a plant engineer, a plant superintendent, and a plant manager. The respondents are indicated next to the items in Appendix 2-1. As individuals within the plant that have first hand knowledge and direct ties to the manufacturing process, the respondents were deemed appropriate for this study. Additionally, the use of multiple respondents adds rigor to the results. With multiple raters, Boyer and Verma (2000) noted that it is critical to assess inter-rater agreement, the degree to which respondents rate items similarly, before aggregating responses. Because the constructs are measured by multiple item scales, the r_{wg} index was used to measure agreement (James et al., 1984; Boyer and Verma, 2000). This index is the within-plant agreement of respondents based on the observed variance of measurement items (James et al., 1984). The average r_{wg} for design, control, and improvement was 0.96, 0.84, and 0.94, respectively. According to James et al. (1984), the acceptable minimum is 0.70. To further validate the inter-rater agreement, random respondents were selected to create 5 dummy plants. Inter-rater agreement was calculated for each plant. The inter-rater agreement for these dummy plants should be less than the value for the real plants. The average values were all less than 0.70. Thus, there is support for inter-rater agreement, and mean responses were used for the subsequent analyses.

A separate EFA was conducted for each construct. The purpose of the EFA was to trim the number of items as needed so that the remaining items constitute a reliable factor measuring a single construct. The goal was to retain at least three items per scale and to identify an *a priori* parsimonious measurement structure for confirmatory analysis (Netemeyer et al., 2003). When measurement scales are modified, the new scales should be assessed using a separate sample for validation (Anderson and Gerbing, 1982; Hair et al., 2006). For that reason, the sample was randomly split, a small subset of plants (N=70) was used to modify the scales through EFA, and the remainder of the sample (N=168) used to confirm the measurement scales. The percentage of plants by country and industry for each sub-sample are shown in Table 2-3.

When conducting the EFA, items were chosen for deletion based upon a number of internal consistency estimates such as change in Cronbach α coefficient (>0.60), squared multiple correlation, item-to-total correlations (>0.35), as well as factor loadings (>0.40), and item wording redundancy (Netemeyer, 2003; Flynn et al., 1994). For each modification, the assumptions for factor analysis were checked. Proper usage of factor analysis can be determined with the Bartlett test of sphericity (Hair et al., 2006) which examines whether the correlation matrix is inappropriate for the factor model. In each case, the null hypothesis was rejected ($p<0.01$), supporting the use of factor analysis.

Measurement items were removed one at a time during the refinement process. A description of the revisions is contained in Appendix 2-2. A few items were on the borderline of meeting statistical criteria, but were retained for the next stage to preserve content validity (Netemeyer et al., 2003). So, 4 items were preserved for process design, 5 for process control, and 5 for process improvement; each set of items was unidimensional. Reliability, the degree of consistency within a set of measurement items, was assessed using Cronbach α coefficient (Cronbach, 1951; Hair et al., 2006). Cronbach α for the EFA sample was 0.67, 0.88, and 0.77 for process design, process control, and process improvement, respectively. Each is close to or exceeds the recommended value of 0.70 for scale reliability (Nunnally and Bernstein, 1994), providing some confidence that, in the validation step, the measurement scales for each factor will be reliable and unidimensional.

2.5 Measurement validation

2.5.1 Results of overall measurement model

Before confirming the measurement scales using SEM, multivariate assumptions of homoscedasticity and normality were checked (Hair et al., 2006). Homoscedasticity was checked using the Levene's test for equality of error variances. The null hypothesis is that the error variance for each item was equal across industry and country. The hypothesis (p>0.01) was supported for all items except PD15 (p=0.002) and PC8 (p=0.007). Therefore, we can conclude that there is no issue with constant error variances. A test of normality was performed for each item using the Kolmogorov-Smirnov and Shapiro-Wilk tests statistic. The null hypothesis is that the data follows a normal distribution and this hypothesis was rejected for 6 of the 14 items (p<0.01). However, Lei and Lomax (2005) found that parameter estimates and standard errors were not significantly different under violations of normality when maximum likelihood (ML) estimation was used in SEM analyses. They also found that several fit indices were not affected under these conditions. Therefore, there is support for conducting the CFA with the SEM technique that uses the ML method of estimation even though some items violate the assumptions of normality.

Confirmatory analysis was conducted using LISREL 8.54 with the covariance matrix as the input (Table 2-4). The hypothesized measurement model for CFA is shown in Figure 2-3. There are 74 degrees of freedom for this model. According to MacCallum et al. (1996), to test for close fit with a power of 0.80, the minimum sample size needed is 161. With an N=168, the statistical requirements for power are met.

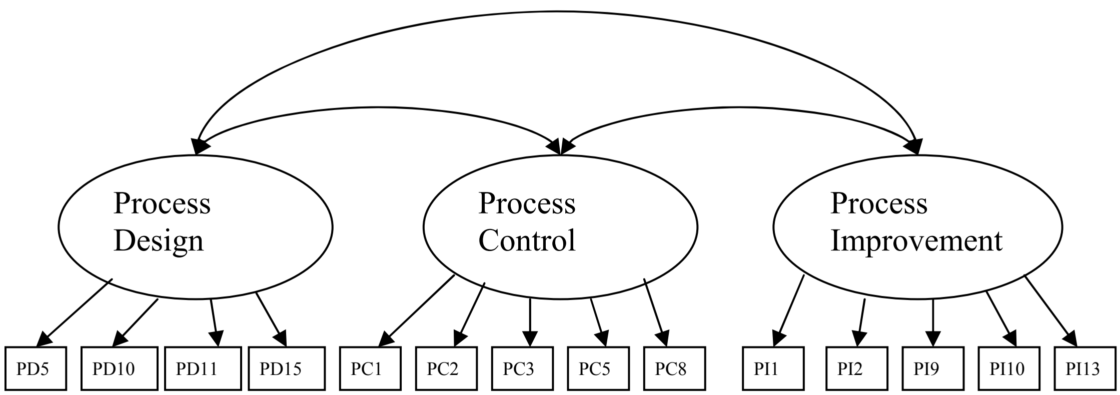

Figure 2-3: Hypothesized measurement model

A variety of absolute and incremental fit indices were used to assess model fit (Hair et. al., 2006; Shah and Goldstein, 2006; Netemeyer et al., 2003; Maruyama, 1998). The fit indices analyzed were χ^2 per degree of freedom (normed χ^2), root mean square error of approximation (RMSEA), standardized root mean squared residual (SRMR), Non-normed fit index (NNFI), Comparative Fit Index (CFI), and largest standardized residual. Absolute fit indices of normed χ^2, RMSEA, standardized RMR, and largest standardized residuals are good measures of model "misfit" since they are based on the residuals between observed input and estimated covariance matrices and are less biased by sample size (Hair et al., 2006; Maruyama, 1998). Good model fit is indicated by standardized residuals less than 2.5, RMSEA less than 0.08, normed χ^2 between 1 and 2, and SRMR less than 0.05. The incremental measures of CFI and NNFI provide additional model fit information by comparing the model to the null model. The common recommended value is greater than 0.90 (Hair et al., 2006; Netemeyer et. al., 2003).

The model converged, but the fit statistics (χ^2/df=3.4, RMSEA=0.12, standardized RMR=0.08, NNFI=0.88, CFI=0.91, largest standardized residual=5.29) indicated inadequate fit. The modification indices indicated some of the error terms for the measurement items should be correlated in order to improve model fit. However, correlating the error terms violates the assumption that the measurement items are independent (Gerbing and Anderson, 1984). In addition, there is no *a priori* theoretical rationale for correlating the errors. According to Anderson and Gerbing (1982), in this circumstance, confirmatory analysis should be performed on each factor separately to assess unidimensionality, reliability, and validity.

Table 2-4: Covariance matrix and descriptive statistics for CFA measurement items

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	PD11	0.556													
2	PD15	0.367	0.934												
3	PD10	0.294	0.418	1.143											
4	PD5	0.208	0.203	0.196	0.447										
5	PI1	0.173	0.118	0.029	0.178	0.481									
6	PI2	0.117	0.08	-0.042	0.069	0.112	0.222								
7	PI9	0.201	0.133	0.173	0.174	0.28	0.099	0.718							
8	PI10	0.212	0.307	0.213	0.162	0.181	0.111	0.304	0.558						
9	PI13	0.188	0.077	0.069	0.17	0.22	0.121	0.303	0.201	0.425					
10	PC1	0.252	0.241	0.534	0.247	0.264	0.067	0.302	0.199	0.099	0.999				
11	PC3	0.179	0.089	0.289	0.088	0.224	0.061	0.504	0.285	0.181	0.478	0.972			
12	PC5	0.368	0.465	0.457	0.305	0.228	0.02	0.487	0.501	0.201	0.657	0.585	1.57		
13	PC6	0.292	0.326	0.413	0.267	0.284	0.105	0.439	0.286	0.211	0.735	0.548	0.669	0.955	
14	PC8	0.252	0.27	0.353	0.219	0.241	0.097	0.35	0.25	0.2	0.512	0.393	0.545	0.538	0.758
	mean	5.082	4.959	4.444	5.232	5.519	6.033	5.048	5.143	5.409	4.864	4.841	3.76	4.842	5.234
	SD	0.746	0.966	1.069	0.669	0.693	0.471	0.847	0.747	0.652	1.001	0.986	1.253	1.08	0.871

2.5.2 Reliability and unidimensionality

In confirmatory factor analysis, unidimensionality is supported when the single factor model exhibits acceptable fit. The model fit statistics for each factor are shown in Table 2-5. Comparing the fit indices to the recommended values listed in the table supports the assertion that each of the constructs exhibits acceptable fit and provides no evidence for a lack of unidimensionality.

Cronbach α and the composite reliability, ρ_c, were used to check scale reliability (Werts et al,. 1974; Netemeyer et al., 2003). The composite reliability is an alternate method to assess reliability by taking into account the factor loadings, thus not using an equal weight for each item (Werts et al., 1974). Both values should exceed 0.70 (Hair et al., 2006). The reliabilities are also shown in Table 2-5. Both Cronbach α coefficient and ρ_c exceed the recommended value confirming acceptable reliability for each factor.

2.5.3 Convergent validity

Convergent validity is a means to assess how well a set of items measure the intended construct (Campbell and Fiske, 1959). The NNFI fit index provides evidence of convergent validity as it compares the hypothesized first order model to the null model. According to Bentler and Bonett (1980), an acceptable value is greater than 0.90. The NNFI for all three factors was greater than 0.90, supporting that the items converge onto their respective factors. Convergent validity was also established by examining the statistical significance of the factor loadings (Anderson and Gerbing, 1988). The factor loadings and t-statistic are displayed in Table 2-5. The t-values for the measurement items range from 6.30 to 14.05, all greater than the critical value of 2.57 ($p<0.01$) demonstrating additional support for convergent validity. Additionally, the largest standardized residual for each construct was less than 2.5, and the normed χ^2 was less than 2.

Table 2-5: Results of factor models

	Process Design	Process Control	Process Improvement	Recommended Values †
Factor loading (t-value)				
PD5	0.52 (6.30)			(t-value > 2.57)
PD10	0.63 (7.72)			
PD11	0.67 (8.31)			
PD15	0.76 (9.41)			
PC1		0.83 (12.57)		
PC2		0.87 (14.05)		
PC3		0.62 (8.69)		
PC5		0.62 (10.24)		
PC8		0.80 (8.89)		
PI1			0.64 (8.12)	
PI2			0.53 (6.51)	
PI9			0.69 (8.82)	
PI10			0.61 (7.58)	
PI13			0.68 (8.60)	
Fit Indices				
RMSEA (p-value)	0.031 (0.45)	0.036 (0.52)	0.064 (0.32)	< 0.08 (> 0.05)
χ^2/d.f.	1.16	1.22	1.68	< 2
Std. RMR	0.035	0.024	0.035	< 0.05
NNFI	0.98	0.99	0.97	> 0.90
CFI	0.99	0.99	0.99	> 0.90
Largest std. residual	1.38	1.89	1.66	<2.5
Reliability				
α	0.70	0.86	0.77	> 0.70
ρ_c	0.74	0.85	0.76	> 0.70

2.5.4 Discriminant validity

Discriminant validity is the degree to which a set of measures is unique to a given construct and has a lack of significant relationship with other constructs (Campbell and Fiske, 1959). Discriminant validity was checked using two methods (Anderson and Gerbing, 1988). First, it was checked by examining the confidence interval (± two std.

error) around the correlation estimates (Φ matrix of factor correlations). If the confidence interval does not contain 1.0, discriminant validity exists. The second method consisted of performing pair-wise comparison of 2 factor models, first with the correlation estimate constrained to equal 1 and then with the correlation free. Discriminant validity is supported when the χ^2 for the unconstrained model is statistically significantly lower than the constrained model[1]. As shown in Table 2-6, the confidence intervals around the correlation estimates do not contain 1, demonstrating strong support for discriminant validity. The results of the pair-wise χ^2 difference tests also indicate that the constructs can be discriminated from one another because they are significant at p-value <0.0167.

Table 2-6: Assessment of discriminant validity

	Unconstrained model χ^2 (d.f.)	Constrained Model χ^2 (d.f.)	χ^2 Difference	Correlation (Confidence interval)
Design w/control	72.7 (26)	152.3 (27)	79.6	0.219 (0.129-0.309)
Design w/ improvement	76.3 (26)	106.1 (27)	29.8	0.146 (0.080-0.212)
Improvement w/ control	131.2 (34)	154.9 (35)	23.7	0.372 (0.244-0.50)

2.5.5 Predictive validity

Predictive validity establishes that the constructs are related to theoretically derived external variables. This type of criterion-related validity is indicated by statistically significant correlations between the predictor measures and the criterion measures (Nunnally and Bernstein, 1994). Based on the literature, it is expected that the

[1] According to Anderson and Gerbing (1988), when conducting tests of multiple pairs, there should be an adjustment to the level of significance. The overall level of significance is 0.05. However, since three pair-wise tests are conducted, the critical significance level for each test is 0.0167 (overall significance level/number of tests). This is equivalent to a χ^2 difference for 1 d.f. of 13.83 or greater.

factors should correlate with customer satisfaction, cost, quality, and delivery. Juran and Godfrey (1999) emphasized that, by incorporating customer needs into the design and improvement of processes, organizations should observe an increase in customer satisfaction. And one priority for plants is to implement a process where product quality is assured of meeting customer requirements consistently (Flynn et al., 1995; Juran and Godfrey, 1999). This can be accomplished by designing an error-proof process, putting controls in place, and fixing any problems that may arise and jeopardize product quality. Additionally, as more statistical control and feedback is used in the process, there should be a reduction in process variation (Flynn et al., 1995; Anderson et al., 1994). This will contribute to better conformance quality, lower manufacturing costs, and improved delivery because fewer products are rejected or reworked, resulting in higher customer satisfaction (Ahire and Dreyfus, 2000; Anderson et al., 1994).

The plant manager rated the plant on unit manufacturing cost, quality conformance, on-time delivery, and customer satisfaction. The selected criterion was scored on a 1-5 Likert scale from *poor* to *superior* as compared to the industry. The responses were collected at the same time, so common method bias (when predictor and criterion measures are "administered as part of a single instrument") could be an issue (Maruyama, 1998, p.89). This, however, is minimized because the predictor variables (process design, process control, and process improvement) were based on multiple respondents and because the predictor and criterion variables do not share a common response format (i.e., they are rated on different Likert scales) (Maruyama, 1998).

Correlations between predictors and criteria for the CFA sample are displayed in Table 2-7. All the correlations are in the anticipated direction and significant except for the relationships between process improvement and conformance quality and process control and conformance quality. These correlations were not significant. Although this is unexpected, it does support the importance of designing processes around specifications and that the design phase is essential to obtaining quality conformance. Despite these results, the remaining correlations provide evidence of predictive validity.

Table 2-7: Correlation results for predictive validity

	Design	Improvement	Control
Improve	0.439**		
	0.00[a]		
	N=168		
Control	0.570**	0.595**	
	0.00	0.00	
	N=168	N=168	
Unit Cost	0.325**	0.228**	0.168*
	0.000	0.005	0.038
	N=152[b]	N=152	N=152
Conformance	0.287**	0.108	0.086
to product	0.000	0.181	0.292
specifications	N=154	N=154	N=154
On-time	0.318**	0.254**	0.298**
Delivery	0.000	0.002	0.000
	N=153	N=153	N=153
Customer	0.209**	0.239**	0.182*
Satisfaction	0.009	0.003	0.024
	N=154	N=154	N=154

** $p<0.01$, * $p<0.05$
[a] Values represent *p*-value
[b] Sample size indicated varies because not all plant managers responded to the criterion items

2.5.6 Post-hoc analysis of factor structure invariance

A post-hoc analysis of the factor structure by country and by industry was performed to examine group differences in factor structure. Since the number of cases is below the desirable quantity for multigroup structural equation modeling, a factor analysis in SPSS was conducted for each group. Although no specific test for group level differences in factor structure was conducted, a visual examination of the factor structure and reliabilities still provided useful information (see Appendix 2-3). For a majority of the countries and industries a single factor was extracted and the reliabilities were acceptable across all three constructs. For process design, the reliability for the data from Finland was slightly below 0.60 and item PD10 loaded onto a second factor (eigenvalue=1.12). For the same construct, the reliability for the electronics industry was 0.56, but a single factor was extracted with high factor loadings. For process improvement, one item in Korea (PI2) loaded onto another factor, but the eigenvalue of that factor (1.05) was very close to the 1.0 cutoff, and these instances may be due to translation problems. Other than for these few exceptions, the factor structure does not vary much across industry or country, thus suggesting a lack of group differences in factor structure.

2.6 Conclusion

The first objective of this essay was to develop a definition of process management. This was accomplished by using literature to deconstruct process management into process design, process control, and process improvement. In order to assess process management in a plant, all three dimensions must be measured. The second objective was to construct and validate a measurement instrument that can measure the elements of process management. Through the use of EFA and CFA, a parsimonious measurement instrument was created. The final objective was to further understand the measurement relationship among the multiple dimensions of process management.

One major contribution of this essay is the identification of a conceptual definition of process management that clearly breaks down process management into process design, process improvement, and process control. Another contribution is the rigorous development and empirical validation of multi-item measurement scales for each element and the operationalization of process management not based on tools and practices. The measurement of these three elements provides a more complete view of process management since it captures information on new and existing processes. The lack of fit with the overall CFA model suggests that there is not a unified construct of process management and that separate distinct elements exist. This may explain the mixed results obtained in previous process management studies. An alternate perspective to the measurement model approach is that the process design, process control, and process improvement are related sequentially, similar to a process maturity model. Organizations first design processes then progress to process control. Over time, an event triggers the redesign or improvement of a process that is changed and then brought back into control (Juran and Godfrey, 1999). Utilizing a process maturity model akin to the capability maturity model (www.sei.cmu.edu) to study process management can be a fruitful area of research.

This study also has important implications for practitioners. A number of companies are becoming more process focused and implementing a variety of process management programs. By uncovering process management and measuring it as three separate dimensions, managers can assess the current state of each element in their organization and, if needed, change the configuration of elements to better support their business.

There are several limitations to this study. One limitation is that the research setting is comprised of only manufacturing plants and focused on manufacturing processes. Consequently, the items for process control focus mostly on statistical quality control. Additionally, process design does not include aspects of process planning which sometimes take place at the divisional or corporate level. Although the content, reliability, and validity of chosen items have been established, additional items from the construct domains may be able to improve the measurement instrument. Future research should include service operations and other types of organizational processes to further validate the measurement instrument.

The use of this measurement instrument can be a helpful aid in future research on process management for researchers and managers. Process management can now be studied through its elements, instead of as a single construct, which can result in richer knowledge. A surprise finding was the poor model fit for the hypothesized three-factor measurement model of process management suggesting that the elements are independent. As a result, researchers must be clear as to which aspect of process management they are studying. Furthermore, it is important to gain a more thorough understanding of the linkages between elements, including the possibility of a longitudinal study to explore these relationships. Future research can examine how external factors influence the configuration of design, control, and improvement within a plant. Similarly, internal factors may also influence the degree of process design, control, and improvement in an operations setting. Investigating interactions with organizational culture, competitive priorities, and process characteristics can be a fruitful research area. Finally, many processes today cross organizational boundaries. An interesting research idea is to investigate how supply chain practices and/or configurations influence how organizations design, control, and improve multi-organizational processes.

Appendix 2-1: Measurement instrument

	Measurement Items	Respondents
Process Design		
PD1	We frequently are in close contact with our customers	DL,QM,SP
PD2	Our customers give us feedback on our quality and delivery performance	DL,QM,SP
PD3	Our customers are actively involved in our product design process	DL,QM,SP
PD4	We strive to be highly responsive to our customers' needs.	DL,QM,SP
PD5	**We regularly survey our customers' needs**	**DL,QM,SP**
PD6	Our organization works to prevent problems, rather than fixing them after they occur	DL,QM,SP
PD7	In our view, quality should be designed into a product, rather than defects inspected out after the fact.	DL,QM,SP
PD8	We think that a good inspection system is more effective and important than a lot up-front design work (reverse)	DL,QM,SP
PD9	We believe that prevention is more effective and economic than repairing undesirable problems	DL,PE,QM
PD10	**Process in our plant are designed to be "foolproof"**	**DL,PE,QM**
PD11	**Our processes are effectively developed and implemented.**	**DL,PE,QM**
PD12	In our view, the process is the entity that should be managed.	DL,PE,QM
PD13	Our customers can rely on us for quality products and processes.	DL,PE,QM
PD14	We often fail to achieve the potential of new process technology (reverse)	PE,PS,SP
PD15	**We pay close attention to the organizational and skill changes needed for new processes**	**PE,PS,SP**
PD16	We believe that organizations should be proactive in anticipating their customers' needs	DL,QM,SP
PD17	We believe that customers are the best judge of their needs and wants	DL,QM,SP
Process Improvement		
PI1	**We strive to continually improve all aspects of products and processes, rather than taking a static approach**	**DL,QM,SP**
PI2	**We believe that improvement of a process is never complete; there is always room for more incremental improvement**	**DL,QM,SP**
PI3	Once a new process is working, we leave it alone (reverse)	DL,QM,SP
PI4	We search for continued learning and improvement after the installation of new equipment	DL,QM,SP
PI5	We believe that process improvements will result in greater quality improvement than human resource initiatives	DL,QM,SP
PI6	In our organization, bringing a variety of perspectives to solving problems leads to better solution.	DL,QM,PM
PI7	We think that the use of specialized quality department will lead to better problem solutions than cross-functional teams (reverse)	DL,QM,PM
PI8	Our view is that teams are appropriate for solving routine problems, but challenging problems should be referred to quality specialists (reverse)	DL,QM,PM
PI9	**Problem solving teams have helped improve manufacturing processes at this plant.**	**DL,QM,SP**
PI10	**Management takes all product and process improvement suggestions seriously**	**DL,SP,PS**
PI11	We are encouraged to make suggestions for improving performance at this plant	DL,SP,PS
PI12	If we aren't constantly improving and learning, our performance will suffer in the long term	DL,QM,SP
PI13	**Our organization is not a static entity, but engages in dynamically changing itself to better serve its customers**	**DL,QM,SP**

Appendix 2-1 (cont'd): Measurement instrument

	Measurement Items	Respondents
Process Control		
PC1	**A large percent of the processes on the shop floor are currently under statistical quality control**	**DL,PE,QM**
PC2	We make extensive use of statistical techniques to reduce variance in processes	DL,PE,QM
PC3	**We use charts to determine whether our manufacturing processes are in control**	**DL,PE,QM**
PC4	Charts showing defect rates are posted on the shop floor	DL,PE,QM
PC5	**Information on quality performance is readily available to employees**	**DL,PE,QM**
PC6	**We monitor our processes using statistical process control**	**DL,PE,QM**
PC7	Charts showing schedule compliance are posted on the shop floor	DL,PE,QM
PC8	**Charts plotting the frequency of machine breakdowns are posted on the shop floor**	**DL,PE,QM**
PC9	Information on productivity is readily available to employees	DL,PE,QM
PC10	Our processes are certified, or qualified, by our customers	DL,QM,SP

Items in bold were retained in the final instrument.
Respondents abbreviated as follows: Quality manager (QM), plant engineer (PE), direct laborers (DL), plant superintendent (PS), supervisors (SP), plant manager (PM)

Appendix 2-2: Description of modification process and assessment of reliability and unidimensionality

Process Design n=70

Dropped PD2, PD3, PD6, PD8, PD9, PD12 per subject matter experts. Remaining items used in EFA.

	Reliability	Factors	Modification for next iteration
Initial EFA		4	Drop PD17, only item to load on factor 4
Iteration 1			Drop PD14, several negative inter-item correlations
Iteration 2			Drop PD7, low item to total correlation
Iteration 3			Drop PD1, low item to total correlation
Iteration 4			Drop PD16, low squared multiple correlation
Iteration 5			Drop PD4, low squared multiple correlation
Iteration 6			Drop PD13, high loading on factor 2
Iteration 7	0.68	1	

Process Improvement, n=70

Dropped PI8, PI6, P11 per subject matter experts panel. Remaining items used in EFA.

	Reliability	Factors	Modification for next iteration
Initial EFA		4	Drop PI7, several negative inter-item correlations
Iteration 1			Drop PI3, several negative inter-item correlations
Iteration 2			Drop PI12, low squared multiple correlation
Iteration 3			Drop PI4, low item to total correlation
Iteration 4		1	Drop PI5, low item to total correlation
Iteration 5	0.77	1	

Process Control, n=70

No items dropped per subject matter experts. All items used in EFA.

	Reliability	Factors	Modification for next iteration
Initial EFA		3	Drop PC10, loaded on factor 3
Iteration 1			Drop PC7, low squared multiple correlation
Iteration 2			Drop PC4, low square multiple correlation, item wording similar to PC5
Iteration 3	0.91	1	Reliability is high suggesting duplicate items, drop PC9, low squared multiple correlation
Iteration 4	0.91	1	Reliability is high suggesting duplicate items, drop PC2, item loading 0.90
Iteration 5	0.88	1	

Appendix 2-3: Analysis of factor structure by country and industry

	Factor Loadings										
Country/industry[a]	FIN	GER	JPN	SWE	USA	ITL	KOR	AUT	E	M	T
Sample size	N=24	N=27	N=25	N=18	N=21	N=17	N=23	N=13	N=54	N=52	N=62
Process Design											
PD5	0.600	0.769	0.671	0.767	0.652	0.608	0.771	0.765	0.519	0.744	0.717
PD10	0.152[b]	0.864	0.840	0.607	0.731	0.637	0.509[b]	0.766	0.634	0.680	0.757
PD11	0.816	0.792	0.872	0.845	0.893	0.801	0.820	0.862	0.760	0.829	0.799
PD15	0.859	0.822	0.736	0.848	0.761	0.798	0.747	0.826	0.740	0.790	0.795
Cronbach α	0.59	0.82	0.79	0.77	0.73	0.64	0.66	0.81	0.56	0.73	0.76
Process Control											
PC1	0.950	0.856	0.900	0.790	0.927	0.933	0.864	0.667	0.886	0.786	0.830
PC2	0.956	0.955	0.900	0.828	0.880	0.927	0.733	0.922	0.899	0.556	0.887
PC3	0.414	0.805	0.690	0.672	0.893	0.918	0.646	0.893	0.755	0.883	0.761
PC5	0.634	0.899	0.785	0.689	0.741	0.851	0.863	0.920	0.739	0.770	0.770
PC8	0.797	0.918	0.704	0.824	0.704	0.621	0.704	0.786	0.633	0.838	0.686
Cronbach α	0.82	0.93	0.85	0.81	0.89	0.89	0.80	0.89	0.83	0.82	0.83
Process Improvement											
PI1	0.787	0.926	0.688	0.640	0.866	0.856	0.811	0.793	0.773	0.759	0.675
PI2	0.649	0.666	0.527	0.830	0.784	0.608	0.377[b]	0.823	0.678	0.566	0.539
PI9	0.724	0.859	0.696	0.739	0.803	0.686	0.576	0.890	0.694	0.815	0.721
PI10	0.845	0.865	0.788	0.423	0.863	0.841	0.799	0.918	0.651	0.694	0.721
PI13	0.599	0.843	0.838	0.873	0.787	0.791	0.857	0.732	0.773	0.813	0.767
Cronbach α	0.75	0.87	0.74	0.73	0.87	0.80	0.70	0.88	0.75	0.78	0.72

[a] Countries and industry abbreviations as follows: Finland (FIN), Germany (GER), Japan (JPN), Sweden (SWE),United States of America (USA), Italy (ITL), Korea (KOR), Austria (AUT), Electronic Industry (E), Machinery Industry (M), Transportation part suppliers (T)

[b] Item that loaded on a second factor

Chapter 3

Pulled in all directions: An empirical examination of the competing values associated with process management

3.1 Introduction

Industry has observed the benefits of process management through the eyes of companies like GE, Motorola, Toyota, and Honeywell. But despite the tremendous success that these companies have experienced, there are many other companies that have not seen such gains in operational performance. Additionally, some organizations have not had a smooth transition when implementing process management practices. The organizational cultures of GE and Toyota are well aligned with their process management efforts, but other companies have had a much more difficult time transitioning to a culture supportive of their process management efforts. For example, 3M wrestled with balancing cultural values associated with efficiency and Six Sigma with differing values associated with design and innovation (Hindo, 2007). These practical examples imply that there may be different value sets associated with different aspects of process management.

Organizations often do not achieve the desired results from process management programs. Neglect of changes needed for the internal organizational environment to support these new initiatives is a potential cause for these unsuccessful programs (Beer, 2003; Juran, 1993; Scott and Cole, 2000). Culture is an "important concept in thinking about organizations since people and processes must combine to produce output" (Armistead and Machin, 1997), and lack of emphasis on creating a supportive organizational culture is often discussed in the literature (Beer, 2003; Deter et al., 2000;

Juran, 1993; Dean and Bowen, 1994; Hackman and Wageman, 1995). Management theorists have emphasized that, when instituting a program like process management, alignment of organizational culture has to occur (Hackman and Wageman, 1995; Dean and Bowen, 1994). So, the links between process management, organizational culture, and plant performance need to be further explored.

Process management is the design, control, and improvement of processes that transfer inputs into outputs (Evans and Lindsay, 2005). Organizations will vary in the use of process design, process control, and process improvement. Regardless of the combination of process management elements, there is an organizational culture that enables that configuration to be effective. Successful process management requires that organizations maintain stable processes (control) while also having the flexibility to change and create new processes (design and improve). Simultaneously, organizations must balance the internal and external perspectives of the business. For example, organizations can be focused on attaining efficiencies and maintaining consistent quality internally, but an external focus is needed to ensure that processes are meeting customer needs and responding to changes in the environment. So a complete process management approach can be difficult to execute because of the tensions between stability and flexibility and internal and external focus. In order to be effective with process design, control, and improvement, organizations must be able to balance these competing tensions.

Culture is defined as a shared set of beliefs, values, and norms (Schein, 2004). Several studies in the operations management field have previously examined organizational culture. Bates et al. (1995) was one of the first studies to investigate organizational culture and its relationship with manufacturing strategy, and Nahm et al. (2004) discovered that organizational culture positively influenced the use of time-based management practices. Other authors, Detert et al. (2000), made a conceptual case for a certain set of values and beliefs that are critical to successful implementation of TQM. These values were based on organizational culture dimensions from the management literature.

There are a number of cultural frameworks in the management literature (Hofstede, 1980; Detert et al., 2000). These frameworks, though, do not capture and theoretically explain the complexity of trying to balance different sets of values. The Competing Values Framework is an organizational culture model based on the competing tensions present in organizations (Quinn and Rohrbaugh, 1983; Denison and Spreitzer, 1991). The ability of organizations to be effective is influenced by their capacity to manage the conflicts of stability versus flexibility and internal control versus external focus. So ultimately, the Competing Values Framework is used in this study to develop a theory of effective process management because of the commonality associated with explaining these differing tensions.

Some recent work has specifically used the Competing Values Framework to study organizational culture in an operations setting. For example, McDermott and Stock (1999) examined how the flexibility and external orientation dimensions were related to Advanced Manufacturing Technique outcomes. This was followed by Khazanchi et al. (2006) who discovered that the congruence of management and worker perceptions on flexibility values was positively related to plant performance.

Although there has been some research that explicitly studies the link between organizational culture and operations management, there is relatively little work that empirically examines the relationship between process management and organizational culture (Cameron and Barnett, 2000). Thus, this essay addresses two primary research questions: first, what types of organizational cultures influence different aspects of process management and, second, how do process design, control, and improvement influence competitive plant performance? The study utilizes the Competing Values Framework to examine the relationship with process management and organization culture. This essay argues that there is an enabling cultural orientation that drives each element of process management and these aspects of process management in turn positively influence plant performance.

This study can help explain the complexity associated with effective process management. Design, improve, and control require different supporting values that make effective implementation of process management more challenging. For example, values associated with creativity, flexibility, and teamwork may be better suited for process design, while values associated with uniformity, consistency, and stability support process control. This essay will show that, in order to be effective in all aspects of process management, an organization must manage these competing values and develop a culture that encompasses diverse cultural dimensions. Establishing a supportive internal organizational environment can be challenging when different dimensions of process management compete for different organizational values. The Competing Values Framework is the best organizational culture framework to uncover the inherent cultural tensions among the three dimensions of process management.

The unit of analysis for this particular research project is the plant level because some organizations implement process management practices across multiple facilities simultaneously, while others may roll it out plant by plant. Process management practices are ultimately used at the plant level even if there is an organization-wide management initiative. Plant level data collection also captures information about management practices where they are used on a routine basis.

The remaining parts of this essay are arranged with a discussion of background and existing literature followed by the conceptual model and hypotheses, proposed in section three. Section four presents the research methods and measurement instrument, with the analysis and results reported in section five. Section six and seven conclude the essay with a discussion of results, implications, limitations, and future research.

3.2 Background

3.2.1 Competing Values Framework

The Competing Values Framework (CVF) was originally developed by Quinn and Rohrbaugh (1983) as a theoretical lens by which to examine organizational effectiveness. It was adapted to organizational culture by Quinn (1988). As Denison and Spreitzer (1991) noted, CVF "focuses on the competing tensions and conflicts inherent in any system: primary emphasis is placed on the conflict between stability and change and the conflict between the internal organization and the external environment." Researchers argue that organizations which can balance the tension between stability, flexibility, and internal and external perspectives are more effective (Quinn, 1988). An illustration of the competing values framework is shown in Figure 3-1. The horizontal axis represents internal versus external focus, and the vertical axis represents stability versus flexibility. A unique cultural type is conceptualized in each quadrant. Organizations can encompass several cultural types, or they may have one or two cultural dimensions that dominate. A description of each cultural type is given based on the works of Quinn (1988), Denison and Spreitzer (1991), and Cameron and Quinn (1999).

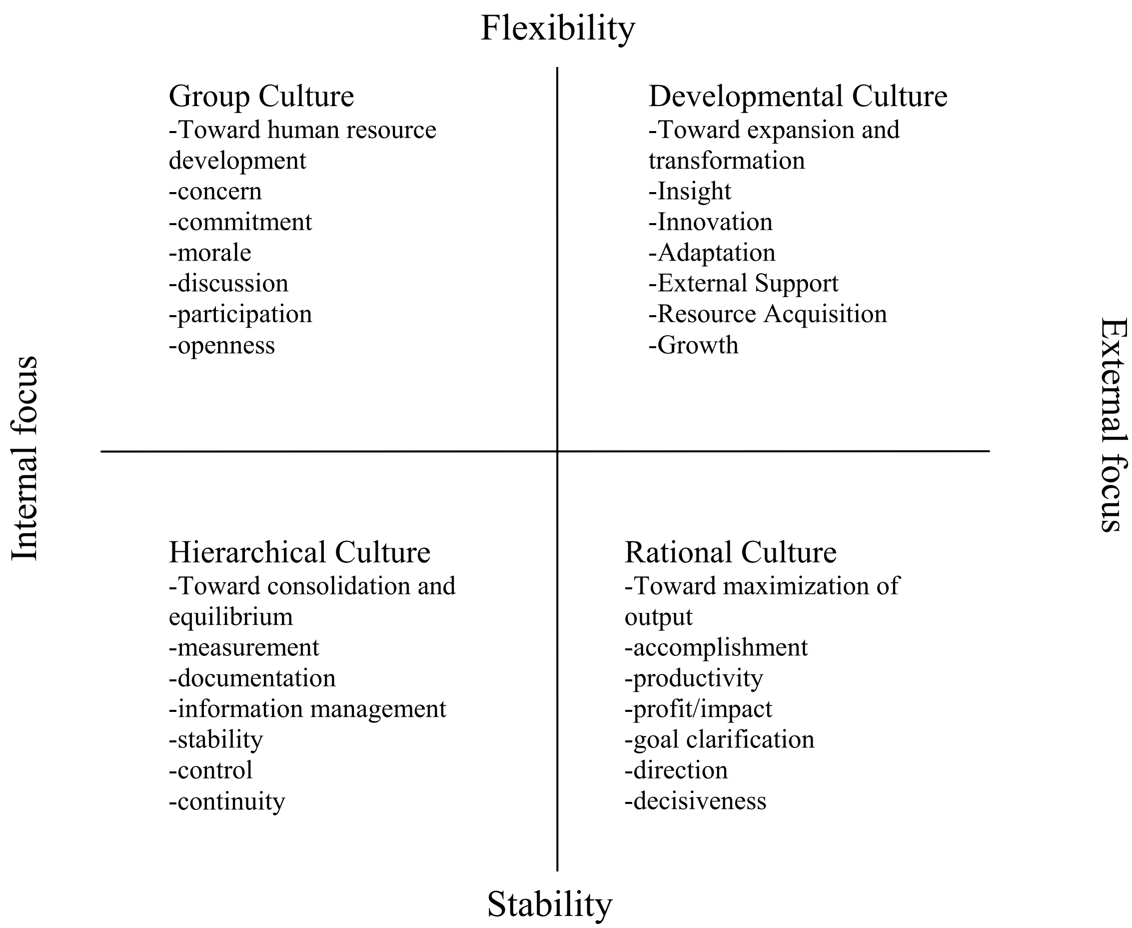

Figure 3-1: Competing Values Cultural Framework
(Source: Quinn, 1988; Denison and Spreitzer, 1991)

The hierarchy culture encompasses stability and the internal organization. This cultural dimension represents values associated with bureaucracy and standardization. Additionally, this type of organization culture values rules and procedures, and decision-making is centralized so that organizational control and order are maintained. The criterion for organizational effectiveness is efficiency demonstrated by the elimination of waste and error-free processes.

Group culture also focuses on the internal organization but embodies the values associated with flexibility (rather than stability). Organizational effectiveness here is achieved through teamwork and human development as this type of organization values togetherness and loyalty. Individual development and employee empowerment are encouraged, and group culture emphasizes shared values, common goals, and consensus on decisions.

The developmental culture emphasizes flexibility with an external focus. Effectiveness in this cultural type is gauged by the production of new products and services. This type of organization culture flourishes in a flexible, dynamic environment, so creativity and adaptability, as well as risk-taking are valued. Capturing new resources and growth drive the developmental culture.

The fourth culture type is rational culture. This cultural dimension is underscored by a stable, externally-focused orientation. A rational culture is driven by the completion of tasks and seeks to increase its competitive position in a stable market by seeking gains in efficiency. Leadership, therefore, stresses setting clear goals and objectives that strive to increase profits and bottom line performance.

3.2.2 Process management and operational performance

A number of studies have investigated the impact of process management on plant level performance. Some of the previous literature has studied process management in the context of Total Quality Management. In these past studies, process management was examined as a single construct within a TQM framework, not as the construct is defined here. Unique to this study is a multidimensional view used to separate the various aspects of process management into process design, process control, and process improvement, which emphasize different values. However, the past literature is important to establish an overall link between process management and operational performance.

When studied as a part of a TQM framework, process management has been shown to have an overall positive effect on operational performance. In one of the earliest studies on TQM, Flynn et al. (1995) found a significant direct relationship between higher levels of process management and lower levels of rework which indirectly yielded a higher competitive advantage. Kaynak (2003) discovered that process management was positively related to operational performance measured by quality, delivery, and productivity. Similarly, in another study of a TQM framework focused on the electronics industry, Yeung et al., (2005) showed that the construct "process control and improvement" is positively related to both time-based and cost-related operational efficiency, as well as customer satisfaction. Despite the support for the relationship between process management and performance, a meta-analysis of quality management studies has revealed mixed results for process management. While process management was shown to be positively correlated with financial performance and customer satisfaction, there was a failure to show a positive correlation between process management and operational performance (Nair, 2006).

Results in prior literature become even more mixed as process management is studied on its own, outside a TQM framework. Process management, as defined in these additional studies, more closely resembles process control and/or process improvement. In one, Ahire and Dreyfus (2000) looked at the effect of process management and design management on quality performance. They found that process management directly affected internal quality and indirectly affected external quality. Process quality was observed to be highly related to customer satisfaction and moderately related to quality performance in a study conducted by Choi and Eboch (1998). Samson and Terziovski (1999) found that process management did not significantly impact organizational performance and was not a strong variable in differentiating strong and weak plants. As well, Powell (1995) discovered that process management was significantly correlated with firm level performance in service organizations, but not significantly correlated in manufacturing firms. Ittner and Larcker (1997) examined several process management practices and their association with return on assets and return on sales in the automotive and computer industry. Results of the relationship between individual practices and firm performance were mixed (Ittner and Larcker, 1997).

3.3 Theoretical model and research hypotheses

The underlying premise of this study is that there are specific cultural types in the CVF that enable effective design, control, or improvement of processes. Figure 3-2 displays the overlap between the CVF and the elements of process management that is the underpinning for the proposed conceptual model.

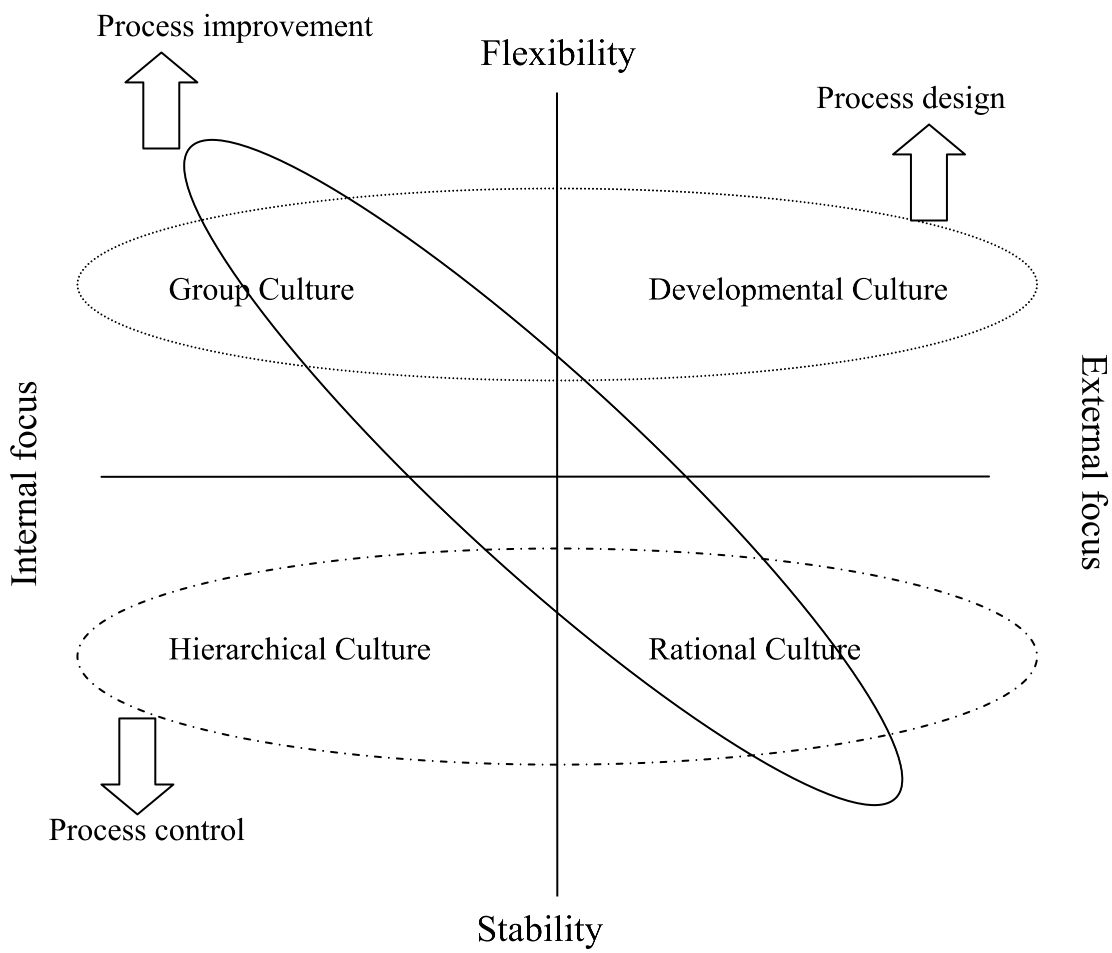

Figure 3-2: Congruent cultures with the elements of process management

In a seminal piece on fit, Venkatraman (1989) conceptualizes fit in multiple ways. Subsequently, there are multiple perspectives on how organizational culture, manufacturing practices, and performance fit together. Beliefs, values, and their artifacts comprise a critical aspect to implementing and sustaining operational practices. Schein (2004) suggests that beliefs and values drive cultural artifacts such as management practices. The theoretical framework tested here proposes that organizational culture is directly related to the dimensions of process management which is then linked to plant performance. Hence, the elements of process management mediate the relationship between culture and performance. This conceptualization of fit as mediation for culture, practice, and performance links was also used in Nahm et al. (2004). The proposed framework is illustrated in Figure 3-3.

3.3.1 Process design enabling culture

Process design is the development of new processes and is a means for adjusting to a changing environment. The design of effective new processes is enabled by the creation of real partnerships with customers so that their needs are met with the new process (Juran and Godfrey, 1999). Plants must be creative and flexible in order to develop and implement new processes rather than trying to continually improve existing processes (Hammer and Champy, 1993). These new processes may require structure changes and employee development.

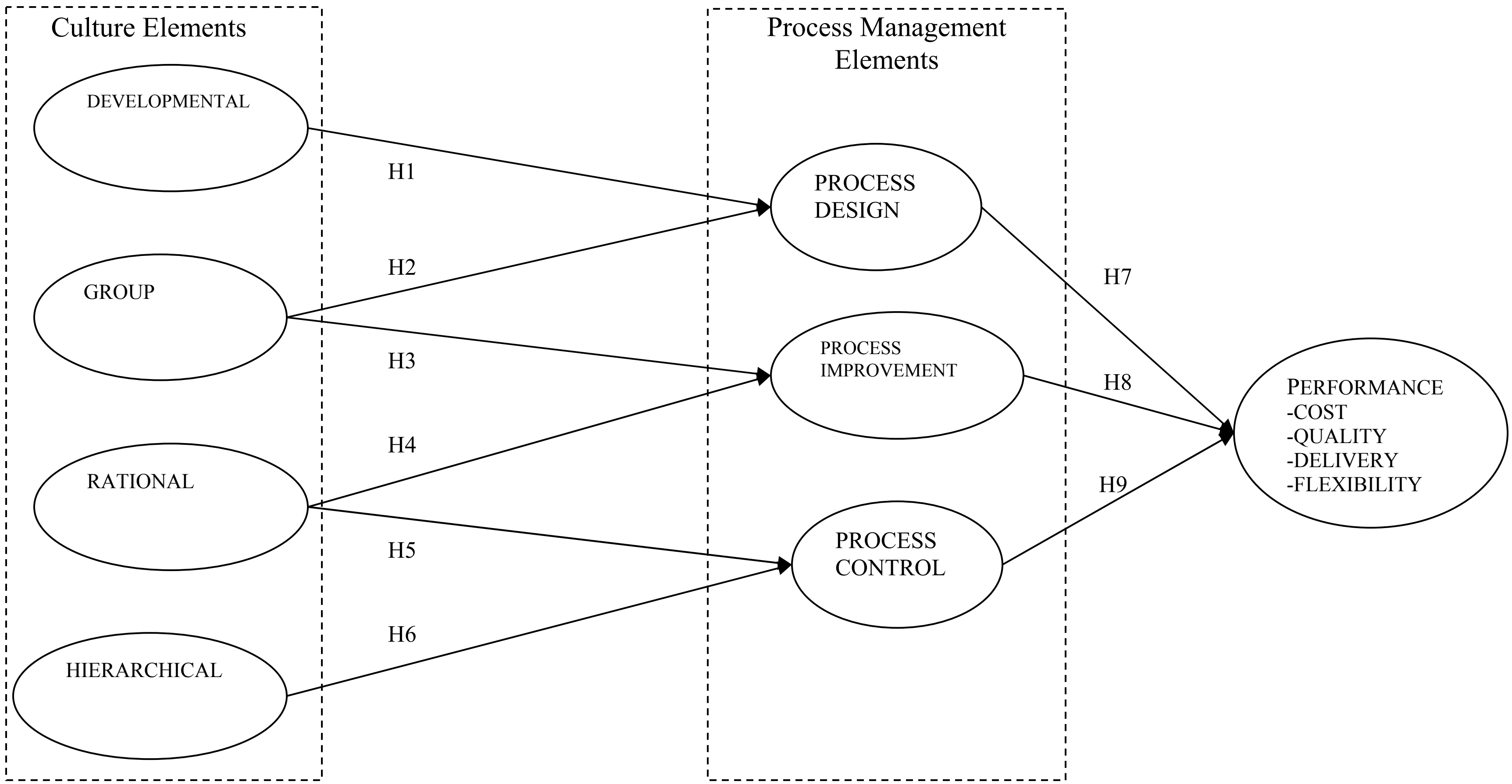

Figure 3-3: Conceptual model

Group and developmental cultures are oriented toward the flexibility dimension that relates to process design. Group cultures emphasize teamwork and employee learning and participation, which are vital to designing a new process. Developmental culture is also compatible with process design activities since this culture values change and innovativeness. The external market focus is essential to developing process so the plant has an accurate understanding of customer expectations. Therefore, the following hypotheses are proposed.

H1: Developmental culture is positively related to process design.

H2: Group culture is positively related to process design.

3.3.2 Process improvement enabling culture

Process improvement is defined as changing existing processes to enhance performance (Evans and Lindsay, 2005). The need to improve processes can be motivated by outside competition or from a reoccurring production issue (Flynn et al., 1995). It may also be the philosophy of the organization to continually improve its processes without some trigger event. Problem solving teams and employee suggestions are often used to improve processes and can result in better plant performance. A culture supportive of process improvement must embrace employee participation, sharing of ideas, and teamwork (Evans and Lindsay, 2005; Dean and Bowen, 1994). Employees are often concerned about the well-being of the company and want the organization to be the best it can. These types of values are affiliated with the group culture orientation.

The rational culture, which emphasizes goal-setting, productivity, and goal attainment, is also hypothesized to enable process improvement. Improvements are geared toward increasing business performance through efficiency and productivity. Many times in manufacturing, improving processes are centered on solving a problem and/or achieving a certain productivity or quality goal. Projects are typically goal-oriented and clearly aim to fix a process problem. Goal setting is a critical component for improving processes (Linderman et al., 2006, 2003), so it is understandable that values associated with being driven to achieve objectives are supportive of process improvement. Additionally, process improvement is enabled when the organization values the customer's perspective and takes it into account when choosing projects and finding solutions that will satisfy them (Juran and Godfrey, 1999). The resulting hypotheses are:

H3: Group culture is positively related to process improvement.

H4: Rational culture is positively related to process improvement.

3.3.3 Process control enabling culture

Process control maintains the consistency and stability of existing processes. The use of process control helps to ensure that not only are goods produced consistently, but they are also produced to meet customer requirements (Kaynak, 2003). Process control is related to efficiency since quality conformance helps to reduce rework, increase yields, lower costs, and improve timely delivery of product (Flynn et al., 1995, Benson et al., 1991; Anderson et al., 1994). Thus, there is an internal perspective of retaining control of products, but also a market perspective of satisfying customers. When plants produce goods that are not meeting customer requirements, the goods must be scrapped or reworked, possibly increasing the time to deliver to the market and, in turn, reducing profitability and customer satisfaction.

In examining the CVF, the proposed supportive cultural types for process control are hierarchical and rational cultures. The market orientation and focus on profitability and competitiveness associated with a rational culture are important to effective process control. A rational culture is customer-focused, which promotes values aligned with ensuring that products consistently meet or exceed customer demands. In the literature, process control techniques are considered an important tool for plants to lower their unit cost, which will influence plant profitability and help plants stay more competitive (Flynn et al., 1995; Kaynak, 2003). Along these lines, it expected that the values for rational culture will be associated with process control.

In a hierarchical culture, the inclination to follow procedures to avoid errors emphasizes the importance of internal control. Uniformity and consistency are also stressed, leading to the production of products with minimal variation. Another critical aspect of process control is the measurement and documentation of process outputs. Measurement of process characteristics such as cycle time, throughput, yield, conformance to specification, and documentation of defects are important to managing internal operations. Without them, plants may find themselves dealing with out of control processes and product quality issues. Hierarchical cultural values emphasize management of information, stability, control, and continuity which are consistent with the manufacturing practice of process control. Thus, the hypotheses are

H5: Rational culture is positively related to process control.

H6: Hierarchical culture is positively related to process control.

3.3.4 Process management and performance.

Process management attempts to improve operational processes (Ahire and Dreyfus, 2000) by multiple means: continuous monitoring, improvement of current processes, and the design and development of new processes. The design of new processes or the radical redesign of existing processes can have a positive effect on operational performance (Hammer and Champy, 1993). In the planning stage, process design should include customer requirements and design elements that will reduce defects, rework, and unit cost (Juran and Godfrey, 1999). Process design or re-design can result in optimized and more efficient processes. Waste removal, simplification, and setup time reduction can be used at this stage to improve productivity.

Process improvement techniques can take many forms (Ittner and Larcker, 1997), all of which aim to enhance the performance of the process. Deming (1986) implied that the focus of process improvement should be on reducing variability. Decreasing variation will increase yields and productivity, impacting cost, quality, and delivery. Processes must also be monitored and controlled to ensure performance (Evans and Lindsay, 2005). Process control tools and techniques are used to track the stability of a process and make certain that the goods are produced consistently and conform to specifications. Operational performance should benefit from process design, process improvement, and process control.

H7: Process design is positively related to plant performance.

H8: Process improvement is positively related to plant performance.

H9: Process control is positively related to plant performance.

3.4 Research design

3.4.1 Data collection

Data were collected in multiple industries and multiple countries through the High Performance Manufacturing Study, Round 3 (HPM). An international group of researchers worked to collect data from 3 industries in 8 countries. The countries were selected as representatives of industrialized countries. The 3 industries of machinery, electronics, and transportation parts suppliers were selected to represent mature industries that compete globally. Plants from the target population were selected from multiple sources including Industry Best Plant Award winners, Shingo Award winners, and general industry lists. A stratified random sample technique was used to attempt to attain an equal number of plants within each country/industry combination. A total of 366 plants were selected for the sample, and telephone calls were placed to plant managers to gain permission for each plant to participate in the study and to identify a plant coordinator to work with the researchers. As a result, data were collected from multiple respondents in 238 plants representing a response rate of 65%. To ensure an adequate amount of management responses, the minimum plant size was 250 employees.

Survey items were created to obtain information on a variety of manufacturing practices, plant demographics, and industry characteristics. Questionnaires were translated to the native language of each country and then back-translated to English to ensure accuracy of translation. Surveys were mailed to a plant coordinator who then distributed the questionnaires to multiple personnel throughout the plant.

Non-response bias is a possible issue with survey data. Following Armstrong and Overton (1977), the sample was divided among early and late respondents. Comparison of total number of employees, percentage of market share, and production sales value shows no statistically significant differences between the two groups. Thus, non-response bias does not appear to be present in the sample.

3.4.2 Measurement instrument

The CVF has been studied within various areas of management. The cultural quadrants in our study were measured using items similar to the original measurement instrument used by Quinn and Spreitzer (1991) and McDermott and Stock (1999). Items were also chosen that were representative of the content domain associated with the constructs of process design, process control, and process improvement. Subject matter experts judged these items as acceptable measurement items that capture the relevant information for each construct. Thus, the content validity of these measures is established. Each item is measured on a 7-point Likert scale. Measurement items are listed in Appendix 3-1.

To improve reliability, data were collected from multiple levels of management in the plant. Some of the respondents include plant superintendent, quality manager, and plant supervisors. Because there were multiple respondents for the culture and process management items, inter-rater agreement was assessed (Boyer and Verma, 2000). The ratio method developed by James et al. (1984) is the most common method to assess inter-rater agreement with an acceptable lower limit of 0.70. For the items in this study, the inter-rater agreement ranged from 0.81 to 0.95. Thus, there was sufficient agreement amongst respondents within a plant. Individual response data were aggregated for each plant to provide a plant level measure for each item.

Competitive plant performance was measured by the separate constructs of cost, quality, delivery, and flexibility. The plant manager responded to subjective indicators used to measure each of these four dimensions of performance. Each measurement item is measured on a 5-point Likert scale (*poor, low end of industry* to *superior*) in which the plant is compared to other plants in its industry on a global basis. Subjective indicators are as effective as objective performance measures according to Ketokivi and Schroeder (2004a). Three indicators for cost were used: unit cost, inventory turnover, and cycle time. Delivery consisted of on-time delivery performance and fast delivery performance. Flexibility was measured by the ability to change product mix and the ability to change volume. Conformance to product specifications and product capability were used as indicators of quality performance. These indicators have been used in several other studies providing evidence of content validity. Item level descriptive statistics are displayed in Table 3-1.

Table 3-1: Pearson correlations, descriptive statistics, and reliabilities

	PD	PI	PC	DEV	GRP	RAT	HIE	C	Q	D	F
PROCESS DESIGN (PD)	1.000										
PROCESS IMPROVEMENT (PI)	0.484**	1.000									
PROCESS CONTROL (PC)	0.542**	0.308**	1.000								
DEVELOPMENTAL (DEV)	0.605**	0.328**	0.480**	1.000							
GROUP (GRP)	0.461**	0.564**	0.136*	0.337**	1.000						
RATIONAL (RAT)	0.520**	0.495**	0.295**	0.378**	0.450**	1.000					
HIEARCHICAL (HIE)	0.319**	-0.287**	-0.115	-0.036	-0.110	-0.243**	1.000				
COST (C)	0.326**	0.256**	0.160*	0.382**	0.106	0.193**	-0.137*	1.000			
QUALITY (Q)	0.248**	0.157*	0.136*	0.323**	0.186**	0.158*	-0.126	0.386**	1.000		
DELIVERY (D)	0.294**	0.257**	0.180**	0.334**	0.193**	0.257**	-0.075	0.392**	0.368**	1.000	
FLEXIBILITY (F)	0.346**	0.252**	0.115	0.321**	0.240**	0.196**	-0.184**	0.364**	0.250**	0.468**	1.000
No. of Obs. (N)	238	238	238	236	237	238	238	216	219	218	218
Mean	5.005	5.511	4.603	5.123	5.38	5.01	3.862	3.35	3.90	3.81	3.89
Standard Deviation	0.685	0.536	1.02	0.771	0.647	0.704	1.156	0.679	0.635	0.768	0.668
Cronbach α	0.730	0.753	0.864	0.813	0.807	0.846	0.882	0.712	0.498[a]	0.606[a]	0.563[a]
Composite reliability	0.774	0.773	0.840	0.812	0.815	0.846	0.883	0.700	0.662	0.753	0.689

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).
[a] Correlation for measurement items. Cronbach's α not applicable to two item scale.

3.4.3 *Method of analysis*

The proposed model is tested via Structural Equation Modeling using maximum likelihood estimation with the item level covariance matrix as the input. The two-step method of testing the measurement model using confirmatory factor analysis prior to the structural model was followed as suggested by Anderson and Gerbing (1988) and Hair et al. (2006). The exogenous latent variables (cultural dimensions) were allowed to correlate. This is warranted, given the structure of the CVF and the literature (Kalliath et al., 1999).

It is possible that cultural values and process management elements could vary by country and industry, thus inducing additional effects in the model. Flynn and Saladin (2006) found that levels of process management varied depending on national culture dimensions. Industry context may also influence the level of control and learning-oriented practices (Benson et al., 1991). Data were standardized by industry and country prior to running analysis to control for potential industry and country effects.

According to Shah and Goldstein (2006), it is critical to investigate missing data, data normality, and statistical power to provide validity to results obtained from structural equation modeling. Missing data can pose a serious issue when conducting analysis if the amount of missing data is greater than 10% as the parameter estimates can change (Tsikriktsis, 2005). The sample size here is reduced due to missing data, but no more than 10% of the plants are missing. The resulting sample size used for analysis is 216, which is the smallest sample size in the correlation matrix listed in Table 1 (Hair et al., 2006). According to MacCullum et al. (1996), this sample size provides adequate statistical power for a model of this size.

Multivariate normality is difficult to test, so an alternate approach is to test the normality of each scale. Normality was tested by comparing the z-value for both kurtosis and skewness to a specified critical z-value of ±2.58, which is a significance level of 0.01 (Hair et al., 2006). There were a few measurement scales that did not pass the normality test. Constructs of rational, improve, and flexibility were non-normal at the 0.01 level with regard to skewness. However, the maximum likelihood estimation technique employed in this analysis is robust enough to estimate when including some items that are not normal (Lei and Lomax, 2005).

Model fit was determined by examining absolute and incremental fit measures as each set of measures provides different information (Maruyama, 1998; Shah and Goldstein, 2006). Indices for absolute fit provide a measure of how well the model reproduces the observed covariance matrix and can be observed by examining the chi-squared value, degrees of freedom, and root mean squared error of approximation (RMSEA) (Hair et al., 2006). Incremental fit indices measure the performance of the proposed model in comparison to a null model. Comparative fit index (CFI) and Normed fit index (NFI) are often used to assess incremental fit in the OM literature.

A separate structural model was analyzed for each of the four performance dimensions to further examine the differing effects of process design, process improvement, and process control on performance. Hypotheses were tested by examining the t-value of the beta or gamma coefficient for the hypothesized links.

3.5 Results

3.5.1 Measurement model results

Prior to assessing the psychometric properties of the measurement items, the overall measurement model must be judged for acceptable fit. Because there are separate structural models for each dimension of performance, two measurement models were created. The first model included the cultural dimensions and elements of process management. The second consisted of the performance measures.

The statistical results for each model are listed in Table 3-2 along with the acceptable criteria levels. The chi-squared value for the first measurement model is 737.37, with 384 degrees of freedom. The performance measurement model has a chi-squared value of 37.76, with 21 degrees of freedom. Examining the chi-square value as an overall measure of fit can be problematic because it is influenced by the number of observed variables (Maruyama, 1998). The normed chi-squared, which is the ratio of chi-squared to degrees of freedom, is an absolute fit measure that is adjusted for the number of observed variables. Values in the range of 1 to 3 are considered acceptable (Hair et al., 2006; Netemeyer et al., 2003). The additional measures of absolute and incremental fit are also within acceptable range for both models. Thus, the measurement models exhibit acceptable fit. The standardized factor loadings are listed in Appendix 3-1, and the phi correlations for each measurement model I and II are listed in Appendix 3-2 and Appendix 3-3, respectively.

Another means for assessing the validity of the measurement model is to examine standardized residuals. Absolute values of standardized residuals greater than 4.0 are considered an issue because they indicate that there is a large difference between the

Table 3-2: Results for measurement and structural models

	Measurement model I	Measurement model II	Cost performance model	Quality performance model	Delivery performance model	Flexibility performance model	Criteria for good model fit[a]
X^2	737.47	37.76	960.34	911.48	916.29	925.28	
d.f.	384	21	480	449	449	449	
X^2/d.f.	1.92	1.80	2.00	2.03	2.04	2.06	1.0 – 3.0
RMSEA	0.062	0.060	0.065	0.066	0.066	0.067	<0.08
CFI	0.94	0.94	0.91	0.91	0.91	0.91	>0.90
NNFI	0.96	0.97	0.95	0.95	0.95	0.95	>0.90

[a] Criteria values from Hair et al. (2006) and Netemeyer et al. (2003)

observed and fitted covariance term (Hair et al., 2006). The largest standardized residuals are 3.90 and 2.09 for the first and second measurement models, respectively, providing additional evidence of good measurement model fit.

3.5.2 Construct reliability and validity

Psychometric properties of convergent validity, discriminant validity, and reliability are critical to establish the overall construct validity. Convergent validity is the degree to which items significantly reflect the construct they are intended to measure (Campbell and Fiske, 1959). Statistically significant factor loadings are a means to establish convergent validity. All factor loadings listed in Appendix 3-1 are statistically significant at the $p<0.001$ level, providing evidence of convergent validity and unidimensionality (Anderson and Gerbing, 1988).

Discriminant validity is the degree to which items are unique to a particular construct and not common to other constructs (Campbell and Fiske, 1959). The pair-wise comparison method was used to evaluate discriminant validity. Constructs are deemed different from one another when there is a significant difference in the chi-square values for nested models in which the correlation between pairs of constructs is set to a value of one and the correlation is free (Anderson and Gerbing, 1988). When comparing multiple pairs, the level of significance should be adjusted to account for multiple statistical tests (Anderson and Gerbing, 1988). An analysis of all pairs of constructs here showed a significant difference for all pairings at the $p<0.001$ level.

Both Cronbach α and the composite reliability were calculated to determine the construct reliability (Cronbach, 1951; Fornell and Larcker, 1981). These estimates are listed in Table 3-2. Cronbach α is often used to assess reliability, but requires a minimum of three indicators per construct (Netemeyer et al., 2003). Therefore, this measure of reliability was not calculated for the constructs of quality, delivery, and flexibility. Also, Cronbach α does not take into account factor loadings. The composite reliability accounts for factor loadings and provides additional confidence of construct reliability (Hair et al., 2006). Both measures of reliability are close to or above the common critical threshold of 0.70 for each construct.

3.5.3 Structural model results

Four models were examined, each with a different performance measure. Fit indices suggest acceptable fit of the models to the data. Fit measures for each structural model are listed in Table 3-2. The ratios of chi-square to degrees of freedom are approximately 2.0 for all models. Similarly, the models have acceptable RMSEA, NFI, and CFI values. For all models, RMSEA ranges from 0.06 to 0.067, NFI and CFI are above 0.9. Since these statistics meet the criteria for good model fit, the structural coefficients can be examined for hypothesis testing.

The results of structural relationships are shown in Figures 3.4-3.7. Beginning with the cultural elements, the results indicate that the developmental culture has a significant strong positive relationship with process design. There is also a statistically significant relationship between group culture and process design, as predicted. The coefficients in all models are significant ($p<0.0001$), lending strong support to H1 and H2.

Hypotheses related to a process improvement enabling culture are partially supported. A clear relationship exists between group culture and process improvement for all models with $p<0.0001$. However, there is a lack of statistical significance with rational culture. The range of t-values for the link between rational culture and process improvement is 0.81-0.87 (p-value ranges from 0.385-0.481) across all four models. So, while there is support for H3, there is a lack of support for H4.

Process control was hypothesized to have a positive relationship with rational and hierarchical cultures. Rational culture does indeed have a positive significant relationship with process control at the $p<0.001$ level, providing support for H5; the results, however show a lack of relationship between hierarchical culture and process control. The p-value is in the range of 0.82 among all four models, thus there is no statistically significant relationship and no support for H6.

The final set of hypotheses examines the relationship between the elements of process management and their individual impact on competitive plant performance. Process design is found to be positively related to quality, delivery, and flexibility at the $p<0.001$ significance level. Process design is also significantly related to cost with a t-value of 2.47 ($p=0.0139$). In contrast, there appear to be no significant relationships between process improvement and competitive performance dimensions of cost, quality, delivery, or flexibility. The links between the competitive performance dimensions and process control were also not statistically significant. Accordingly, H7 is supported, but H8 and H9 are not.

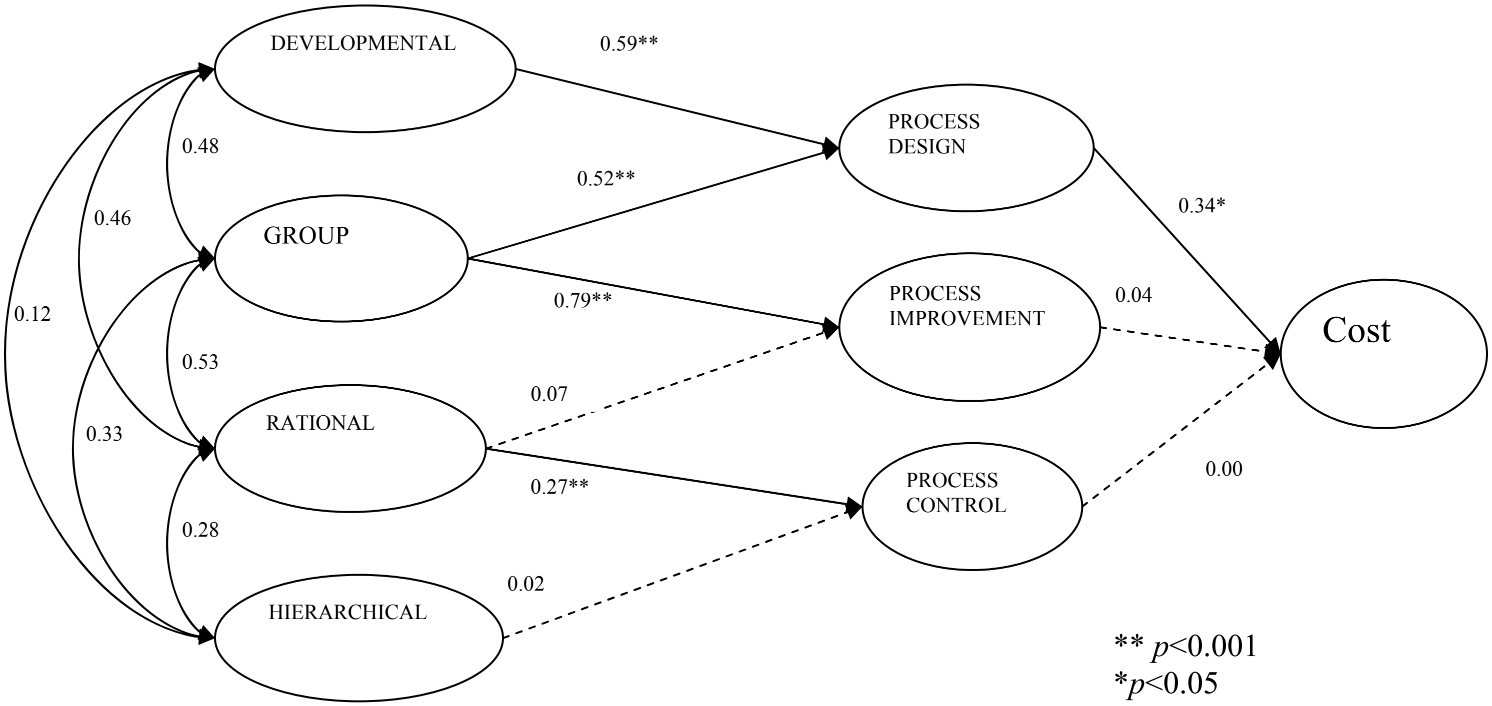

Figure 3-4: Results of hypothesized with cost performance

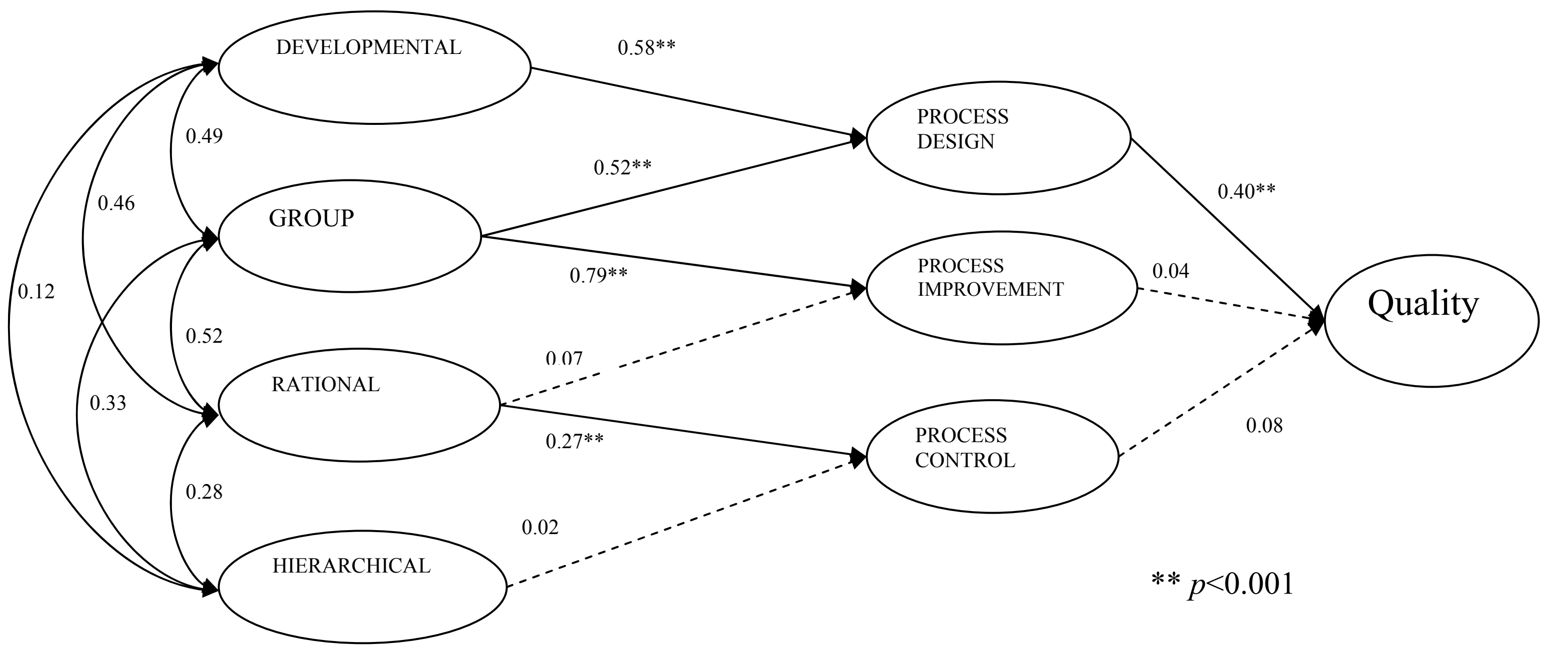

Figure 3-5: Results of hypothesized model with quality performance

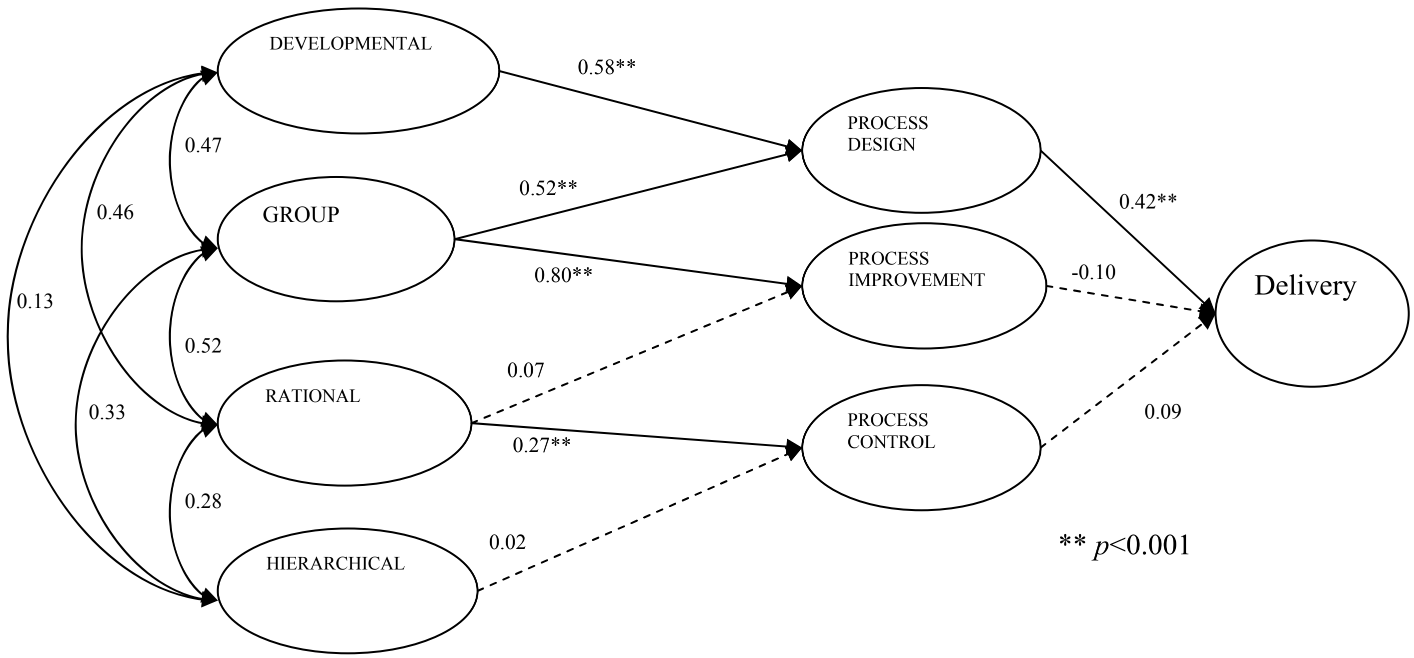

Figure 3-6: Results of hypothesized model with and delivery performance

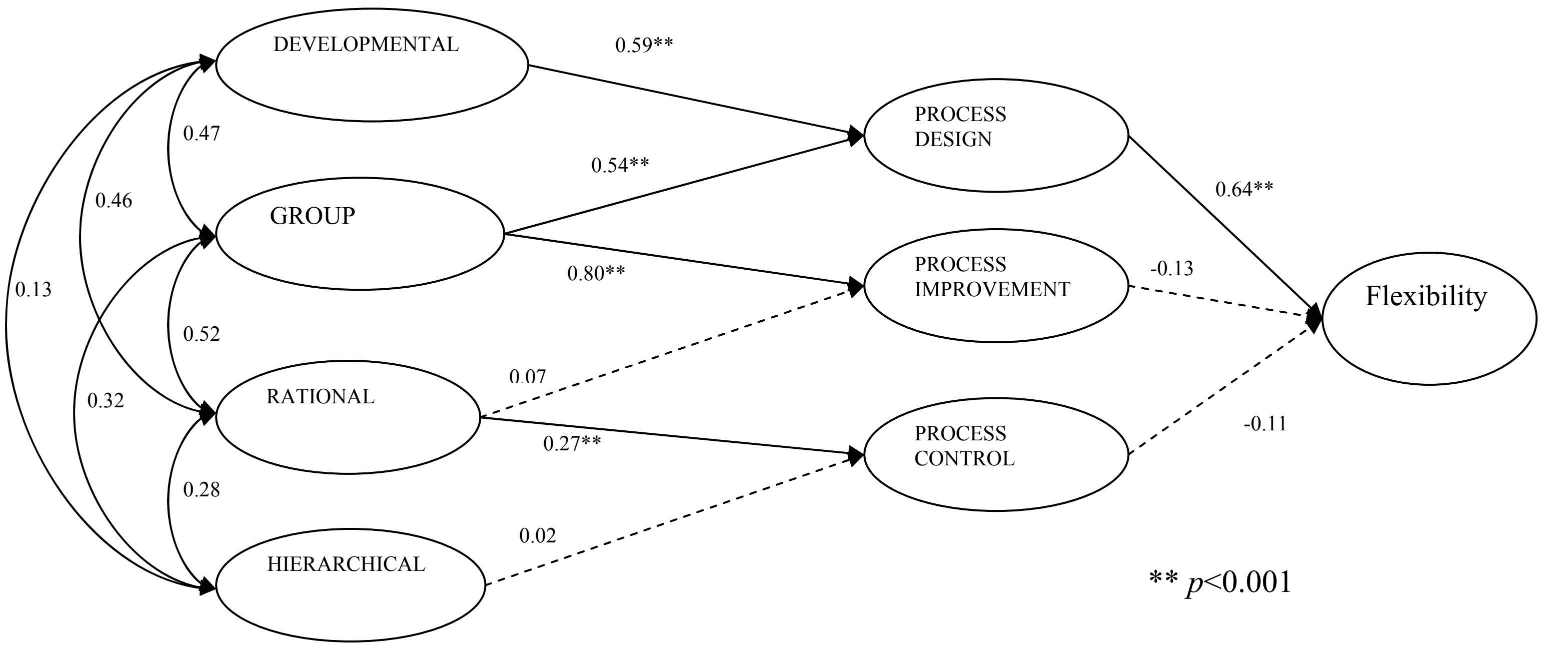

Figure 3-7: Results of hypothesized model with flexibility performance

3.6 Discussion

The analysis indicates that there is a significant relationship between CVF and process management and that the different components of process management are supported by a diverse set of cultural values. Process design is enabled by both developmental and group cultural orientations. The flexibility dimension associated with each of these cultural types is a necessary aspect for process design, as a flexible orientation helps organizations to adapt to new products, environmental uncertainties, and market changes (Quinn and Spreitzer, 1991). Organizations that have an external focus toward the market and competition can use this information in the development and implementation of new processes. Further, an external orientation helps to identify customer needs which should be incorporated not only into the product design, but understood for the design of the process, too (Ahire and Dreyfus, 2000). From a group culture standpoint, designing new processes is often a cross-functional effort including many personnel. Within manufacturing, for example, new process design would involve direct laborers and supervisors, but also engineers. A group culture helps to facilitate communication and openness to other ideas which are necessary when developing new processes.

As expected, process improvement is supported by an organizational culture that values group interaction, teamwork, cohesion, and idea sharing. As with designing new processes, improving existing processes often takes place within team projects (Anderson et al., 1994). Valuing the opinion of others and a sense of common purpose helps motivate creative problem solving for process related issues (Hackman and Wageman, 1995). An open-minded approach and seeking feedback from others involved in the process can trigger additional ideas for improvement. The characteristics of group culture are also supportive of individual level process improvement efforts. Deming (1986) discussed how workers should want to improve their own work processes. Group-oriented cultural values will help create an environment where workers are empowered to not only share ideas, but to individually improve certain aspects of the manufacturing process.

A rational culture does not appear to influence organizations' ability to enhance their manufacturing processes. Although values associated with a rational culture hinge on goal accomplishment and productivity, they are also oriented toward stability. Change is the essence of process improvement. Organizations need to be flexible enough to allow changes to the process. A focus on stability and consistency may stifle the ability to change and improve. Additionally, while an external focus on competition may trigger a need to improve a process, many process improvement projects are actually initiated based on the internal discovery of process issues or suggestions from workers and management. In examining the contrasting tensions of the CVF, the findings suggest that process improvement is better supported by cultural values that are internally-focused and flexible as opposed to values that are oriented toward stability and externally-focused.

A rational culture is important when it comes to practicing process control. Goals and objectives related to process and product quality are essential to operating a plant. Process control oriented practices are often implemented to monitor performance toward these goals. Process control is supported by this type of culture because process control is focused on obtaining process feedback to ensure that the process output conforms to standards and that the process is reliable (Juran and Godfrey, 1999). Statistical tools and techniques are key components for maintaining consistent processes that are the foundation for maintaining operational stability and maximizing output. The information gathered is used to help plants become more productive by eliminating defects, increasing yields, and increasing efficiency (Flynn et al., 1995; Kaynak, 2003). A rational culture is associated with maximizing output, and the values are based on goal accomplishment and productivity, providing a cultural type conducive to the use of process control practices.

Process control is not enabled by a hierarchical culture. The hierarchical culture quadrant is described as an internal focus on stability (Quinn and Spreitzer, 1991). The link between this cultural type and process control was insignificant. Although the value set is focused on stability and control, the bureaucratic nature of this cultural value does not seem to be of vital importance to effective process control. Thus, it appears that process control is enabled by a goal-driven culture, not a bureaucratically-oriented culture. The hierarchical culture exhibits higher levels of formalization and is a mechanistic type culture. A hierarchical culture can become too rigid and too controlling of routine tasks (Adler and Borys, 1996). This mechanistic culture provides a less supportive environment for process-related quality practices (Spencer, 1994). Juran and Godfrey (1999) noted that a critical aspect of process management is empowering employees to have input into the quality of the work. Employees must have not only the ability, but the authority to identify and correct process problems as they occur. Toyota, for example, is famous for its culture of encouraging employees to stop the line to correct a process that is no longer under control (Liker, 2004). This sense of responsibility is infused into Toyota's culture, empowering individuals to make timely decisions. Centralized decision-making reduces an employee's opportunity to take care of process problems as the issues occur because the employee does not have the power to make decisions. The hierarchical culture with its emphasis on rules, procedures, and formalization diminishes employee empowerment.

In summary, the rational, developmental, and group cultures are related to process design, control, and improvement in different ways. Taken together, these cultures represent the tension between internal and external focus and stability and flexibility orientations. Given the fact that three cultures are related to process management affirms the difficulty in balancing cultures that are oriented toward all three elements of process management.

Maintaining these different sets of values may be more difficult than expected. Organizational culture is considered an intangible resource for many organizations (Hall, 1993). Researchers have noted how a strong organizational culture can become an invaluable asset (Peters and Waterman, 1982). The Resource Based View suggests that culture can be a source of competitive advantage, as it is an aspect of the organization that is valuable, unique, and not easy to imitate (Barney, 1986). The complexities of embedding these different value sets into a supportive culture can help to explain the challenges in implementation and institutionalization of process management. Those plants that have uncovered how to sustain this type of enabling culture give themselves an advantage over the competition.

It is equally important to acknowledge the inherent tension between designing new processes, improving existing processes, and maintaining existing processes and the effect on performance. Notably, the outcome of the elements of process management in relation to competitive performance was surprising. Conventional wisdom would say that organizations with higher levels of process control and improvement should have better performance than those with lower levels of these practices. However, it appears that process improvement and control are not factors in differentiating high performing from low performing plants. This is consistent with findings by Samson and Terziovski (1999) and Nair (2006). Powell (1995) points out that quality tools are not as important as the culture that supports the tools. Instead of simply focusing on the practices, organizations should concentrate on creating a culture that will help those practices flourish (Powell, 1995).

One possible reason for the lack of significant relationship between process control, process improvement, and competitive performance is that a majority of plants are using various tools and techniques to monitor process stability and improve processes, neither of which provides any competitive advantage. Researchers note that process improvement and control are essential for plants to remain competitive in today's environment and can impact objective operational performance (Flynn et al., 1995). These practices are vital, but may not provide the adequate means plants need to outperform the competition. This is analogous to Hill's (2000) concept of order qualifiers and order winners in which process control and improvement could be order qualifiers and process design an order winner. Order winners and qualifiers are "market- and time-specific" and so they will change over time (Hill, 2000). As times change and more plants begin to adopt certain mainstream practices, we should expect that those practices may not have the same effect on differentiating high performing plants. As plants begin to institutionalize similar practices, the differentiating effect of those practices may dissolve over time and become a natural part of the manufacturing environment, as opposed to a unique, inimitable resource that provides a competitive advantage. Hence, these practices may be necessary for plants to compete, but plants must implement additional practices to surpass the competition.

An alternate explanation is that the relationships between process improvement, process control, and operational performance may be contingent upon other factors. The context in which these practices are applied could potentially influence their relationship with plant performance (Sousa and Voss, 2001). Nair (2006) indicates "that moderating factors influence [the] relationship of process management with operational performance." Klassen and Menor (2007) suggest the degree of labor intensity and outsourcing strategies as potential moderators for process management. Size and implementation timing are other possible moderators for quality related management practices (Hendricks and Singhal, 2001). Likewise, environmental characteristics such as environmental uncertainty and rate of change may also influence the relationships between these elements of process management and cost, quality, delivery, and flexibility.

The design of new processes turns out to be a significant factor in distinguishing higher plant performance. The level of process design in a plant is positively linked to competitive performance. Plants can establish a competitive advantage by planning and implementing new processes to support the changing environment. Organizations can also maintain a step ahead of the competition by monitoring their customers' needs and incorporating the customers' desires into the process.

3.7 Conclusion

This study has two purposes. The first objective is to determine what types of organizational culture enable different aspects of process management. The second objective is to examine the relationship between the elements of process management and competitive plant performance. The central finding is that effective process management is difficult due to the varying effects of the components of process management on plant performance in addition to the range of cultural values needed to provide a supportive environment for the use of those process management practices.

From this study, there are some stimulating practical implications. First, it provides empirical support for the notion that there are different cultural values associated with different aspects of process management. Specifically, for organizations that are trying to balance the design of new processes with the maintenance and improvement of existing manufacturing practices, managers must realize that these techniques are enabled by different cultural streams. That is, for an organization that does not value innovative thinking, teamwork, and change, it can be difficult to successfully sustain process design efforts. The same can be argued for the other cultural enablers of process control and process improvement. This may be a reason why some organizations have such a difficult time implementing and infusing a process management system throughout the organization.

With the wide spread phenomena of Lean and Six Sigma, more organizations are implementing tools and techniques focused on process improvement, process design, and process control. Process improvement and process control are not directly related to competitive performance, but are practiced by many plants. As such, they remain essential manufacturing practices. Although improving and controlling processes are not a source of competitive advantage, *not* actively improving and controlling processes can serve as a disadvantage. To obtain an advantage, managers must also focus efforts on designing new processes that will lend themselves to achieving improved operational results.

The conclusions of this study are interesting; there are, however, some limitations that deserve to be addressed. First and foremost, scholars of organizational culture have differing opinions on how to conduct culture specific research. In using the CVF, this study remained consistent with other research using this popular cultural framework by using survey-based subjective items measured on a Likert scale (Quinn and Spreitzer, 1991; McDermott and Stock, 1999). Alternate research methods such as case studies can be used in future studies to further these findings.

The research setting is manufacturing plants in the industries of transportation parts suppliers, electronics, and machinery. Replicating this research in service settings such as hotels, hospitals, and restaurants or government and non-profits may trigger different results. These industries have more recently started to focus on the different aspects of process management, so some practices like process improvement may not be industry-wide and may be shown to provide a competitive advantage.

Examining organizational culture in an operations setting is a fruitful area of research. In this and many other cultural studies, the survey respondents were management personnel, which is a limitation. Future research should extend to capture the values and beliefs of shop floor personnel. Similarities between shop floor and management views can then be investigated to identify whether within plant value congruence has an effect on process management and plant performance. Additionally, more work could be done to discover where different cultural orientations lie within an organization. For example, it may be that developmental cultural values reside more with the plant manager and engineers and group values reside more with production supervisors and direct laborers. This would be an interesting and natural extension of this work.

This study provides a starting point for future research by recognizing that there are three components of process management: design, control, and improvement. Not all three of these components are related to the same type of culture, and they are differentially related to performance. It is hoped that the results from this study will spur further research on process management.

Appendix 3-1: Measurement items and factor loadings

Culture Constructs		Measurement Items Likert scale 1- 7 (*strongly disagree to strongly agree*)	Std. beta	t-values*
Group Culture	GRP1	Our supervisors encourage the people who work for them to work as a team.	0.78	13.50
	GRP2	Our supervisors encourage the people who work for them to exchange opinions and ideas.	0.76	12.98
	GRP3	Our supervisors frequently hold group meetings where the people who work for them can really discuss things together	0.70	11.65
	GRP4	Generally speaking, everyone In the plant works well together	0.65	10.55
Developmental Culture	DEV1	We pursue long-range programs, in order to acquire manufacturing capabilities in advance of our needs	0.64	10.30
	DEV2	We make an effort to anticipate the potential of new manufacturing practices and technologies	0.83	14.79
	DEV3	Our plant stays on the leading edge of new technology in our industry	0.62	9.98
	DEV4	We are constantly thinking of the next generation of manufacturing technology	0.77	13.25
Rational Culture	RAT1	In our plant, goals, objectives and strategies are communicated to me.	0.48	7.59
	RAT2	Our incentive system encourages us to vigorously pursue plant objectives.	0.90	17.24
	RAT3	Our reward system really recognizes the people who contribute the most to our plant.	0.72	12.45
	RAT4	The incentive system at this plant encourages us to reach plant goals.	0.90	17.08
Hierarchical Culture	HIE1	There are few levels in our organizational hierarchy (reverse coded)	0.76	13.44
	HIE2	Our organization is very hierarchical	0.68	11.42
	HIE3	There are many levels between the lowest level in the organization and top management	0.88	16.46
	HIE4	Our organizational chart has many levels	0.90	17.30

Process Management Constructs		Measurement Items Likert scale 1- 7 (*strongly disagree to strongly agree*)	Std. beta	t-values*
Process Design	PD1	We pay close attention to the organizational and skill changes needed for new processes.	0.70	11.80
	PD2	Our processes are effectively developed and implemented.	0.79	13.96
	PD3	We regularly survey our customers' needs.	0.54	8.55
	PD4	Processes in our plant are designed to be "foolproof".	0.55	8.39

Process Management Constructs		Measurement Item Likert scale 1- 7 (*strongly disagree to strongly agree*)	Std. beta	t-values*
Process Improvement	PI1	We strive to continually improve all aspects of products and processes, rather than taking a static approach	0.65	10.55
	PI2	We believe that improvement of a process is never complete; there is always room for more incremental improvement	0.52	7.49
	PI3	Our organization is not a static entity, but engages in dynamically changing itself to better serve its customers	0.66	10.76
	PI4	Problem solving teams have helped improve manufacturing processes at this plant.	0.63	10.12
	PI5	Management takes all product and process improvement suggestions seriously	0.74	12.25
Process Control	PC1	Charts plotting the frequency of machine breakdowns are posted on the shop floor.	0.59	9.54
	PC2	Information on quality performance is readily available to employees.	0.56	8.98
	PC3	A large percent of the processes on the shop floor are currently under statistical quality control.	0.85	15.62
	PC4	We use charts to determine whether our manufacturing processes are in control.	0.68	11.28
	PC5	We monitor our processes using statistical process control.	0.87	15.99

Performance Constructs		Measurement Items Likert scale 1-5 *(poor, low end of industry to superior*)	Std. beta	t-values*
Cost	C1	Unit Cost	0.46	6.21
	C2	Inventory turnover	0.71	10.16
	C3	Cycle time (from raw materials to delivery)	0.79	11.36
Quality	Q1	Conformance to product specifications	0.76	9.32
	Q2	Product capability and performance	0.64	8.27
Delivery	D1	On time delivery performance	0.83	11.56
	D2	Fast delivery	0.72	10.01
Flexibility	F1	Flexibility to change product mix	0.69	9.09
	F2	Flexibility to change volume	0.76	9.94

* All t-values are significant at $p<0.001$ level.

Appendix 3-2: Phi correlations for measurement model I

	DEV	GRP	RAT	HIE	PD	PI	PC
DEVELOPMENTAL (DEV)	1.000						
GROUP (GRP)	0.45	1.000					
RATIONAL (RAT)	0.44	0.62	1.000				
HIEARCHICAL (HIE)	-0.10	-0.29	-0.29	1.000			
PROCESS DESIGN (PD)	0.83	0.74	0.63	-0.29	1.000		
PROCESS IMPROVEMENT (PI)	0.51	0.78	0.57	-0.31	0.80	1.000	
PROCESS CONTROL (PC)	0.54	0.28	0.23	-0.06	0.63	0.48	1.000

Appendix 3-3: Phi correlations for measurement model II

	C	Q	D	F
Cost (C)	1.000			
Quality (Q)	0.61	1.000		
Delivery (D)	0.51	0.52	1.000	
Flexibility (F)	0.54	0.38	0.62	1.000

Chapter 4

The impact of process management on innovation and efficiency performance: the moderating effect of competitive intensity

4.1 Introduction

Due to today's competitive pressures, organizations must engage in activities that will generate high performance and a competitive advantage. Many organizations are turning to process management initiatives like Lean and Six Sigma as a means to help them achieve and sustain their competitive advantage. Yet, in order to effectively compete over time, organizations have to perform well in both efficiency and innovation (Abernathy, 1978). These dual dimensions pose a potential issue for plants implementing process management (Sitkin et al., 1994; Sutcliffe et al., 2000).

Process management is described as the design, control, and improvement of processes (Evans and Lindsay, 2005). Quality gurus such as Deming and Juran charge that process management is universally beneficial to any organization. Research results on the impact of process management on efficiency related performance measures are mixed. Ahire and Dreyfus (2000), for example, reported that process management positively impacted performance, while others have showed that process management has no real impact on operational performance (Samson and Terziozski, 1999; Nair, 2006).

Existing literature also suggests that process management requires a tradeoff between innovation and efficiency outcomes. Process management is positioned as a management practice that places too much attention on improving efficiency, thereby hindering a firm's ability to focus on innovation through exploration (Benner and Tushman, 2002). Benner and Tushman (2003) argued that "process management techniques stabilize and rationalize organizational routines while establishing a focus on easily available efficiency."

Previous research has focused on the direct effects of process management on performance. The resulting paradoxical outcomes may be resolved by including environmental contextual variables (Nair, 2006). Contingency theory says organizational outcomes are influenced by the fit between the environmental context and the organization's processes and structures (Donaldson, 2001). Some researchers have suggested that the effectiveness of process management is dependent on the task environment which is representative of the market environment (Sutcliffe et al., 2000; Sitkin et al., 1994). Empirical research has yet to examine how the competitive dynamics faced by an organization impact the effectiveness of process management.

Dynamism is a measure of environmental instability based on the rate and unpredictability of change (Dess and Beard, 1984). Uncertainty increases as the environment changes because often organizations can not fully anticipate the degree of change and the impact that change will have on the organization (Miller, 1992). One critical factor of environmental dynamism is competitive pressure or intensity (Dess and Beard, 1984). Competitive intensity can be defined as the strength of competitors' ability to influence a focal firm's action. "Competitive intensity shifts the level of analysis from the market to the organization" (Barnett, 1997). As the intensity of competition increases, organizations are forced to become more innovative with products and processes in order to remain competitive. Auh and Menguc (2005) note, "when the competition is less intense, firms can operate with their existing systems to fully capitalize on the transparent predictability of their own behavior. However, when competition is intense, firms will have to adapt accordingly." Thus, the level of competitive intensity of an organization's external environment may play a pivotal role in the effectiveness of that organization's process management efforts.

The objective of this essay is to examine the moderating role of competitive intensity on the relationship between process management and performance. Specifically, this essay seeks to address how competitive intensity influences the impact of process management on efficiency and innovation performance. Apart from previous studies, an alternate view of process management is used in this analysis. Process management is analyzed through its three components of process design, process improvement, and process control. Using the literature on organizational learning, this essay argues that the dimensions of process management involve first- and second order learning (Adler and Clark, 1991). These aspects of learning link process management to innovation and efficiency performance. The potential impact of the fit of process management with the competitive environment is explained using contingency theory. Regression is used to test fit as moderation by examining the interactions of process management and competitive intensity. The next section will provide the theoretical foundation and conceptual development. This is followed by a description of the data, analysis, and results. The essay concludes with a discussion of the findings, contributions, and future research ideas.

4.2 Theory and hypotheses

4.2.1 Theoretical foundation

Process management consists of the design, improvement, and control of organizational processes (Evans and Lindsay, 2005). Process control is defined as monitoring existing process conditions to ensure stability and consistent performance (Juran and Godfrey, 1999). Maintaining a stable process can occur through the use of statistical quality control, standard operation procedures, checklists, etc. Process improvement is the changing of existing processes to enhance performance and has been practiced in organizations for decades as exemplified by Taylorism.

The third element of process management, process design, is the development and implementation of new processes. The traditional view of process management hinges on the concepts of process control and process improvement, but all three components are critical aspects of process management (Silver, 2004). The process design component is associated with defect prevention and new product introduction (Deming 1986; Ahire and Dreyfus, 2000). Process design includes error proofing new processes so that defects are minimized (Evans and Lindsay, 2005; Juran and Godfrey, 1999).

Theory relating process management and performance draws upon the organizational routines and organization learning literature. Routines are patterns of interactions that occur repeatedly. A process is an organizational routine (Becker, 2004). These routines can be viewed as a source of stability or flexibility (Feldman and Pentland, 2003). Nelson and Winter (1982) define organizational routines as a "pattern of behavior that is followed repeatedly, but is subject to change if conditions change." In essence, organizational routines are developed, maintained, and revised as needed.

Routines that modify routines are described as meta-routines (Adler et al., 1999). Consequently, process management can be considered a meta-routine. Process control is a mechanism to maintain organizational processes and ensure stability. Process design and improvement change routines by either enhancing existing processes or creating new ones.

As organizations manage routines, organizational learning will occur (Nelson and Winter, 1982). Adler and Clark (1991) discussed organizational learning in the context of manufacturing processes by examining two types of learning: first order learning and second order learning. First order learning is associated with "learning based on repetition and on the associated incremental development of expertise" (Adler and Clark, 1991). Incremental learning that comes from learning by doing occurs, for example, as workers repeatedly perform the same set of activities. First order learning is core to process control and process improvement. Second order learning is associated with higher levels of cognitive thinking and a better understanding of causation that is not apparent through repetition (Fiol and Lyles, 1985). This is fundamental for process improvement, but also process design, where a deeper understanding of the relationship between work activities is needed when developing and implementing new processes.

Learning is the underlying mechanism that relates design, improvement, and control with performance. Process management is proposed to have a significant relationship with efficiency and innovation performance contingent on the level of competitive intensity. Figure 4-1 illustrates the conceptual model.

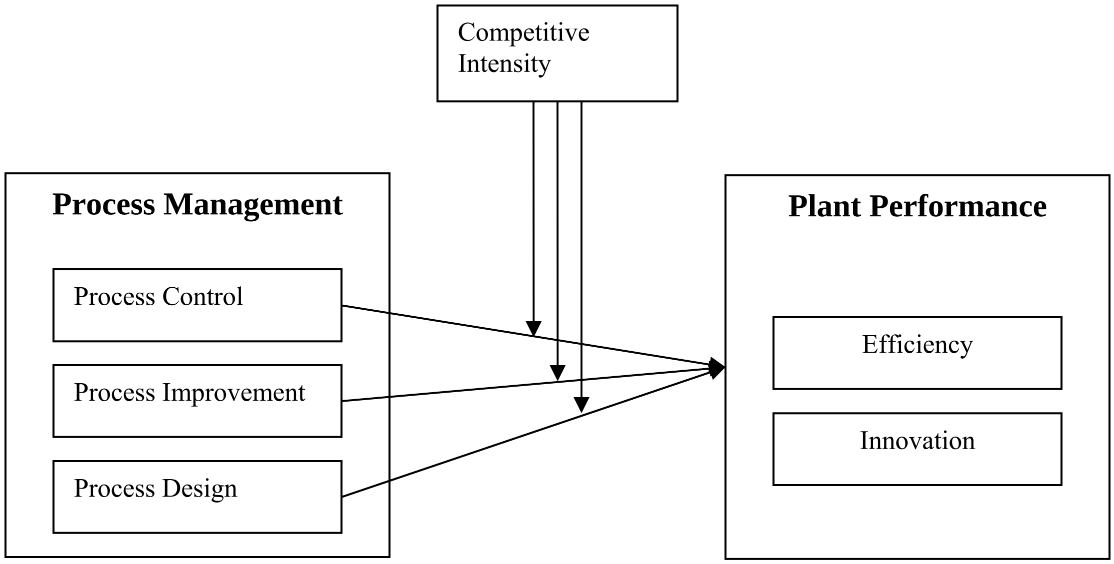

Figure 4-1: Conceptual relationship

4.2.2 Process management and efficiency

To be efficient, plants must quickly and effectively produce product with little waste. Gains in efficiency occur by producing a consistent product that conforms to product specifications. Process control focuses on identifying and removing defects, helping plants to meet product and process quality goals (Juran, 1992). Employees increase their ability to identify defects because of the incremental learning that occurs from actively performing the same recurring tasks (Repenning and Sterman, 2002; Upton and Kim, 1998). Process control can reduce the need for rework, thereby favorably impacting process cycle time and efficiency (Hackman and Wageman, 1995; Klassen and Menor, 2007).

Process improvement ideas also come through incremental learning. As employees become more proficient in their tasks, ideas are generated on how to perform the job more effectively. Further, organizations should encourage a learning environment where improvement ideas reflect a deeper understanding of the process, which is characteristic of second order learning (Sitkin et al., 1994; Repenning and Sterman, 2002). Higher levels of knowledge can be created through the use of cross-functional teams and other knowledge creation and sharing practices associated with process improvement (Choo et al., 2007; Mukherjee et al., 1998). Increased productivity is a product of continuous process improvements that reduce errors, reduce variance, lower cost, and improve cycle time (Juran and Godfrey, 1999). Hence, process improvement can also result in gains in efficiency.

Adler and Clark (1991) noted that second order learning occurs as organizations "transform the goals of the process by explicit managerial or engineering action to change the technology, the equipment, the processes, or the human capital in ways that augment capabilities." This transformation can occur through process design with the development and implementation of new processes. However, disruption due to the introduction of new processes may not lead to more efficient operations until organizations have adapted to the new technology (Leonard-Barton, 1988). Yet, over time, it is assumed that the new processes will lead to better operating performance (Tyre and Hauptman, 1992). Thus, it is expected that:

H1: Process control positively influences efficiency performance.

H2: Process improvement positively influences efficiency performance.

H3: Process design positively influences efficiency performance.

4.2.3 Process management and innovation

High innovation performance requires flexibility and is a result of an organization successfully adapting to changes in the environment (Donaldson, 2001). Innovation requires that organizations go beyond learning from repetition, defect correction, and a desire to reducing process variation. The development of new technologies and products requires that organizations engage in practices which, for some period of time, increase process variation. This higher order learning may require changes in technology, people, or both (Adler and Clark, 1991; Repenning and Sterman, 2002). Experimentation and flexible routines are keys to learning that can lead to better innovation performance (Benner and Tushman, 2003).

Process control is centered on minimizing variation and considered a hindrance to the introduction of variance that is associated with the launch of a new product (Benner and Tushman, 2003). However, other management research on innovation argues that control is critical for flexible adaptation. Some variance reduction efforts may help innovation by reducing some uncertainty associated with the development of a new product or process (Eisenhardt and Tabrizi, 1995), however, according to Benner and Tushman (2002), they also constrain an organization from engaging in the higher order learning activities that are needed for process innovation. Organizations often get trapped in a learning cycle focused on making incremental improvements, minimizing their ability to engage in variance enhancing activities which lead to product and process innovation (Argyris, 1976; March, 1999). Focusing on process control may detract from those organizational efforts that can foster a competitive advantage in the area of innovation.

Seemingly inherent in this argument is the idea that process improvement is linked with lower levels of learning. However, variance enhancing activities can lead to process improvements that are applied to existing processes. Furthermore, some new products are built off of existing platforms that don't require a radical redesign or a new process (Tushman and Anderson, 1986). Even for products that require new technology or processes, process improvement may be necessary (Tyre and Hauptman, 1992). Incremental improvements can be beneficial during the transfer or scale up of a process into a manufacturing setting.

In addition, the competitive landscape for innovative firms is always changing and the assumptions that the existing processes are built on may no longer be correct, thus requiring the development of new processes (Hammer and Champy, 1993). Process design is necessary for radical technology changes which support innovation (Benner and Tushman, 2003) and is essential for innovative plants to remain competitive (Evans and Lindsay, 2005). New product innovation may also come with new customer requirements that should be incorporated into the process design phase (Juran, 1992). Process design practices support the flexibility and experimentation that is needed to foster innovation.

H4: Process control negatively influences innovation performance.

H5: Process improvement positively influences innovation performance.

H6: Process design positively influences innovation performance.

4.2.4 *Impact of competitive intensity*

Some researchers consider process management to be a management initiative that is universally beneficially to organizations (Deming, 1986; Juran and Godfrey, 1999). This best practice philosophy and institutionalization of practices are exemplary of the institutional theory mimicry argument (Scott, 2001). As organizations become successful and increase organizational effectiveness with the use of various management initiatives, other organizations begin to adopt these same actions as "best practices." Omitted from this theoretical perspective is consideration of individual environmental contexts and their influence on the effectiveness of these practices (Benson et al., 1994; Sitkin et al., 1994; Sousa and Voss, 2001; Ketokivi and Schroeder, 2004b).

The work of Katz and Kahn (1978) and Lawrence and Lorsch (1967) brought to the forefront the important role of the environment and its effect on the design and work of organizations. Katz and Kahn highlighted organizations as open systems impacted by and responsive to environmental factors. Thus, it is essential that the environment is reflected in organizational processes. Lawrence and Lorsch extended systems theory and proposed that organizational effectiveness is influenced by the degree of fit between an organization's structure and processes and its environment. The basic tenet of this contingency theory is that the processes of an organization must match its environmental context in order to be effective (Drazin and Van de Ven, 1985). In a dynamic environment, the existing structures and processes may no longer be suitable and organizational performance may suffer. In order to remain competitive, organizations are forced to change to achieve the necessary level of fit to enhance their performance (Donaldson, 2001). Dynamic competitive environments exist in organizations that compete on either low cost or differentiation (Porter, 1980). Competitive pressures reside in different strategic settings requiring organizations to understand their competitive environment and choose processes that are most effective within that context.

Each element of process management can help to achieve gains in efficiency, but the magnitude of these gains is contingent on the environment. In highly competitive environments, it is more difficult to achieve competitive priorities of cost, quality, delivery, flexibility, innovation, and service (Ward and Duray, 2000). When operating in a highly competitive environment, plants have to implement management initiatives that are going to result in greater productivity. Gains in efficiency can occur by producing a consistent product and continually improving existing processes. But as competition increases, these aspects of process management become even more necessary. In failing to adopt these practices, a plant is unlikely to keep pace with productivity gains achieved by competitors who are implementing better processes utilizing superior equipment and technologically advanced tools.

In a competitive environment, plants may also be forced to create new or redesigned processes more frequently as they try to thrive in a rapidly changing environment (Donaldson, 2001). However, plants in a less competitive environment will not have to create new processes as often. Plants in a fiercely competitive environment should experience a greater operational benefit from process management than plants in a less competitive environment.

H7: Competitive intensity will positively moderate the relationship between process control and efficiency performance.

H8: Competitive intensity will positively moderate the relationship between process improvement and efficiency performance.

H9: Competitive intensity will positively moderate the relationship between process design and efficiency performance.

Process management has been criticized as a management system that focuses too heavily on reducing variation and errors in a process. Process control is focused on maintaining stability in an organization through carefully monitoring existing processes. Organizations have limited resources and capabilities and, when firms focus on efficiency-supportive activities, it leaves less room for innovation-supportive activities. The changing nature of dynamic environment requires organizations to compete through innovation and adaptability (Brown and Eisenhardt, 1997; Tushman and Anderson, 1986). Process control restricts an organization's ability to be flexible to changes and can negatively influence innovation performance. This negative relationship will be exaggerated in a highly competitive environment where change is essential to survival.

Changing processes and creating new processes support the introduction of new products, and they are essential to adapting to technological change and competitive pressures. This is heightened in a dynamic competitive environment where the level of adaptation needed is higher than in a static environment. So, process improvement and design should have an even stronger effect on innovation performance as the intensity of competition increases.

H10: Competitive intensity will negatively moderate the relationship between process control and innovation performance.

H11: Competitive intensity will positively moderate the relationship between process improvement and innovation performance.

H12: Competitive intensity will positively moderate the relationship between process design and innovation performance.

4.3 Methods

4.3.1 Data collection

Data were collected as part of the third round of the High Performance Manufacturing (HPM) research project. This is an international study that contains data from eight countries across the machinery, electronics, and transportation parts supplier industries. The study uses a stratified random sample technique in an effort to obtain an equal number of plants across industries and country. Plants are randomly selected from a number lists such as *Industry Week* Best Plant Award winners, Shingo Prize winners, and industry lists. Consent to participate in the study was obtained from plants prior to mailing questionnaires. A battery of questionnaires was sent to each plant to gather data on a variety of manufacturing practices including process management activities and manufacturing performance, hence the unit of analysis is the plant. In return for participation, at the close of the study each plant received a profile summarizing their response information as well as a comparison to other plants within the same industry. Data were obtained from one plant per firm to ensure independence in the sample. The sample size is 238 plants. This study uses only a portion of the measurement items from the data set. After assessing the data, there are missing data for 2 plants, so the effective sample size is 236. This is less than 10%, thus it is not considered an issue (Tsikriktsis, 2005).

The response rate across countries is about 65%. Even with a high of response rate, non-response bias was examined since it can pose problems in survey-based research (Malhotra and Grover, 1998). Non-response bias was examined by comparing early respondents to late respondents. Armstrong and Overton (1977) suggest that late respondents can be considered similar to non-respondents, and this approach is often used in OM studies. A two-sample t-test was conducted on sample characteristics of total number of employees, total sales value of production, and market share. Early and late respondents were also compared on the independent and dependent variables in this study. There were no significant differences ($p>0.05$) between early and late adopters.

4.3.2 Measures

Independent variables

The scales for process design, process control, and process improvement were developed based on previous literature and expert opinion from the field of OM. The items, measured on 1 to 7 Likert scale of *strongly disagree* to *strongly agree*, can be found in Appendix 4-1. There were multiple respondents for each measurement item. The respondents included direct laborers, supervisors, a quality manager, a process engineer, a plant superintendent, and a plant manager. The respondents work closely with the manufacturing process and would have adequate knowledge of the plant's process management activities. There was an average of 8 respondents per plant for each process management measurement item. To determine whether responses should be aggregated, inter-rater agreement was examined (Boyer and Verma, 2000). According to James et al. (1984), when assessing inter-rater agreement for multiple item scale, a within-group agreement metric, r_{wg}, can be calculated for each plant and then averaged across the plants. The inter-rater agreement for each measurement scale was above the critical r_{wg} value of 0.70, and the responses were aggregated.

The psychometric properties for process design, process control, and process improvement are also listed in Appendix 4-1. Three factors emerged using principal components analysis with Varimax rotation (Hair et al., 2006). Measurement items loaded on the anticipated factor with all loadings greater than 0.40. There was no significant cross loading of measurement items. Cronbach α is used to determine internal consistency. Scales with reliability above 0.70 are deemed acceptable (Cronbach, 1951), and the reliability scores for process design, process control, and process improvement are 0.73, 0.86, and 0.76, respectively.

Competitive intensity scale is measured on a 1-7 Likert scale of *strongly disagree* to *strongly* agree. Boyd et al. (1993) noted that subjective measures of the environment can possibly introduce a large degree of error because the measure relies on the ability of the respondent to accurately assess the environment. To reduce the perceptual bias, multiple respondents (plant manager, plant superintendent, and process engineer) answered the measurement items. Inter-rater agreement is above 0.70, and Cronbach alpha is 0.69.

Dependent variables

The measurement item responses for innovation and efficiency were obtained from the plant manager and are listed in Appendix 4-2. Innovation is measured by items related to new product introduction and product innovation—typical measures of innovation (Devaraj et al., 2001). Efficiency is measured by items related to speed, cost, and quality. All items are measured on a 1-5 Likert scale of *low* to *superior relative to global, industry competition*. Principal component analysis with Varimax rotation revealed two dimensions. Items loaded together as expected, except for the measure on conformance to product specifications, which loaded significantly on both factors and, therefore, was dropped. The resulting factor structure can be found in Appendix 4-2 with all factor loadings greater than 0.40. Cronbach α for innovation performance is 0.77 and 0.72 for efficiency performance.

When using survey data, common method bias could pose an issue. The issue of common respondent bias between the independent and dependent measures is minimized since the measures have multiple and different respondents and are measured on different Likert scales (Maruyama, 1998).

Control variables

Although the analyses do not specifically investigate the influence of country and industry, these dichotomous variables are included in the analyses as control variables to take into consideration differences in performance that may be due to location or industry characteristics. Additionally, plant size is included as a control variable and is measured as the natural logarithm of total number of employees.

The last control variable included is process type. Process type is based off the product/process matrix (Hayes and Wheelright, 1984) and can potentially impact efficiency and innovation. For example, continuous processes are highly capital-intensive, but are associated with higher volume outputs and are considered more efficient. Process type is measured as an index based on the percentages of various process types within the plant. This approach is similar to that used in Devaraj et al. (2001). The process engineer asked to characterize the processes within the plant. The index for process type was calculated as:

Process type = (1 x Process A + 2 x Process B + 3 x Process C + 4 x Process D + 5 x Process E)/100

Where:

Process A	% of one of a kind
Process B	% of small batch
Process C	% of large batch
Process D	% of repetitive/line flow
Process E	% of continuous flow

Descriptive statistics and correlations are shown in Table 4-1.

Table 4-1: Descriptive statistics, correlations, and scale reliabilities

	Variables	Mean	S.D.	Correlation 1	2	3	4	5	6	7	8
1	Innovation Performance	3.43	0.760	0.78[a]							
2	Efficiency Performance	3.55	0.570	0.498**	0.72						
3	Design	4.98	0.680	0.308**	0.392**	0.73					
4	Improve	5.47	0.480	0.197**	0.302**	0.512**	0.76				
5	Control	4.64	0.930	0.175*	0.263**	0.605**	0.539**	0.86			
6	Competitive Intensity	5.64	0.639	0.081*	0.144**	0.327**	0.196**	0.196**	0.69		
7	Size	6.00	1.029	0.161*	0.117	0.238**	0.091	0.197**	0.255**	-	
8	Process type	3.06	1.402	0.054	0.176*	0.101	0.006	0.281**	0.103	0.337**	-

[a] Cronbach α is displayed along the diagonal for measurement scales. It does not apply to size and process type.
** Significant correlations $p<0.01$
* Significant correlations $p<0.05$

4.3.3 Analyses

Hierarchical regression analysis using Ordinary Least Squares (OLS) was used to assess the impact of process design, control, and improvement on innovation and efficiency performance and the moderation effect of competitive intensity. Several regression models were tested for each dependent variable. The base model includes control variables as indicator variables. The second model includes the control variables plus main effects of process design, process improvement, process control, and competitive intensity. The third full model includes all of the previous indicators plus the interactions of competitive intensity with each element of process management.

At each regression step, the significance in the change in R^2 were tested to determine overall significance of the added variables. The significance and direction of the beta coefficients were examined to test the hypotheses. Regression coefficients for the interaction terms were interpreted prior to the main effects; if the interaction terms are significant, then the impact of the main effects associated with the interaction variables are more difficult to interpret (Kutner et al., 2005). In the case of a significant interaction variable, a significant main effect does not represent a constant effect, but rather a conditional effect (Aiken and West, 1991). Significant interactions were further studied using two interaction-probing techniques of conditional effect plots (Kutner et al., 2005) and simple slope analysis (Jaccard et al., 1990).

There are a number of assumptions associated with multivariate regression (Hair et al., 2006). Linearity, homoscedasticity, normality, and presence of outliers were examined prior to performing the regression analyses. Analyses of the residuals plotted against the predicted values exhibited no violation of homoscedasticity, and a plot of the standardized residuals supported the normality assumption. An examination of the independent and dependent variables shows that there were no observations with a standard score ±2.5, indicating that there were no outliers present (Kutner et al., 2005).

Multicollinearity within the independent variables can pose a problem when conducted OLS regression (Kutner et al., 2005). To reduce the effect of multicollinearity induced with the interaction terms, the data were mean-centered prior to creating the interaction terms (Kutner et al., 2005). Additionally, the variance inflation factor was examined to identify any multicollinearity issues. Some suggest a VIF cutoff of 10 (Hair et al., 2006; Kutner et al., 2005). Cohen and Cohen (1983) use more stringent criteria and suggest the acceptable cutoff is a VIF of less than 3.0. An assessment of the variance inflation factor for the independent variables confirms some degree of multicollinearity. This is no surprise given the observed of correlation between the variables. However, the VIF here was less than 3.0, which is under the acceptable limit.

4.4 Results and discussion

4.4.1 Efficiency performance results

The regression results for the relationship between process design, improvement, and control and efficiency performance can be found in Table 4-2. The first model is the base model with only control variables included. Main effects were added for model 2, which is significant at the 0.005 level. The change in R^2 is significant and the adjusted R^2 is 15.3%. For model 3, the addition of the interaction terms of competitive intensity and each element of process management also yielded an overall significant regression model. Results show that that neither the interaction terms of competitive intensity with process control nor process design is significant. The interaction term of competitive intensity with improvement (H8) and the main effect of process improvement (H2) are both significant at the $p \leq 0.05$ level. This main effect represents the conditional effect of process improvement on efficiency at the mean of competitive intensity (Aiken and West, 1991). The main effect of process control is not significantly related to efficiency performance; however, process design is significantly positively related to efficiency performance ($p \leq 0.01$) and supportive of H2.

4.4.2 Innovation performance results

The results for the overall significance and change in R^2 for the hierarchical regression models with innovation performance as the dependent variable are listed in Table 4-3. The F statistic and the change in R^2 are statistically significant as main effects and interactions are added to the model. The full model, model 6, is significant with an adjusted R^2 of 10.2%. Both the interaction terms for competitive intensity with control and with improvement are statistically significant in their respective predicted directions, providing support for H10 and H11. The interaction of competitive intensity with process design is not significant; however, the main effect of process design is highly significant at the $p \leq 0.005$ level, supporting H6. Process design has a strong positive relationship with innovation performance in spite of the level of competitive intensity.

Table 4-2: Regression results for efficiency performance

	Model 1		Model 2		Model 3	
	Beta[a]	SE	Beta	SE	Beta	SE
Constant	3.041	0.330	3.408	0.334	3.455	0.334
Electronic	-0.040	0.111	-0.138	0.108	-0.121	0.108
Auto Suppliers	0.083	0.109	0.000	0.106	0.006	0.104
Finland	-0.075	0.190	-0.206	0.182	-0.235	0.182
Germany	0.289	0.179	0.070	0.185	0.051	0.184
Japan	0.145	0.192	0.104	0.198	0.166	0.202
Sweden	-0.109	0.199	-0.156	0.193	-0.185	0.193
Italy	0.070	0.189	-0.014	0.181	-0.044	0.181
Korea	0.329	0.226	0.139	0.231	0.149	0.228
Austria	0.193	0.219	-0.121	0.227	-0.131	0.226
Plant size	0.031	0.051	0.005	0.050	-0.006	0.050
Process Type	0.044	0.038	0.036	0.037	0.033	0.037
Process Control (PC)			-0.010	0.059	-0.017	0.058
Process Improvement (PI)			0.137*	0.056	0.130*	0.056
Process Design (PD)			0.165*	0.068	0.171**	0.067
Competitive Intensity (CI)			-0.065	0.056	-0.069	0.057
PC x CI					0.060	0.063
PI x CI					0.093†	0.058
PD x CI					-0.001	0.061
R^2	0.100		0.223		0.254	
change in R^2			0.123***		0.031†	
Adj. R^2	0.042		0.153		0.170	
F	1.731		3.195***		3.105***	

[a] unstandardized beta coefficient reported

***$p \leq 0.005$, **$p \leq 0.01$, *$p \leq 0.05$, †$p \leq 0.1$

Table 4-3: Regression results for innovation performance

	Model 4		Model 5		Model 6	
	Beta[a]	SE	Beta	SE	Beta	SE
Constant	2.7576	0.4191	3.0797	0.4355	2.9279	0.4353
Electronic	0.065	0.141	0.001	0.141	-0.038	0.141
Auto Suppliers	-0.038	0.138	-0.109	0.137	-0.109	0.136
Finland	-0.146	0.242	-0.259	0.237	-0.156	0.238
Germany	0.250	0.227	-0.071	0.240	-0.017	0.239
Japan	0.029	0.243	-0.153	0.257	-0.051	0.263
Sweden	-0.100	0.252	-0.181	0.251	-0.144	0.251
Italy	-0.163	0.240	-0.264	0.236	-0.175	0.231
Korea	-0.270	0.286	-0.565†	0.300	-0.580†	0.297
Austria	-0.095	0.278	-0.497†	0.295	-0.436	0.293
Plant size	0.102	0.065	0.084	0.066	0.098	0.066
Process Type	0.025	0.049	0.030	0.049	0.041	0.047
Process Control (PC)			-0.065	0.076	-0.069	0.078
Process Improve (PI)			0.048	0.074	0.062	0.073
Process Design (PD)			0.285***	0.088	0.270***	0.088
Competitive Intensity (CI)			-0.095	0.073	-0.111	0.074
PC x CI					-0.170*	0.082
PI x CI					0.129†	0.069
PD x CI					0.025	0.072
R^2	0.074		0.158		0.191	
change in R^2			0.085***		0.033†	
Adj. R^2	0.014		0.082		0.102	
F	1.227		2.081*		2.144**	

[a] unstandardized beta coefficient reported

***$p \leq 0.005$, **$p \leq 0.01$, *$p \leq 0.05$, $^{\dagger}p \leq 0.1$

4.4.3 Analysis of interaction effects

Jaccard et al. (1990) and Aiken and West (1991) suggest that significant interaction effects in multiple regressions should be further explored to better understand the meaning of the interaction. The previous analysis provides statistical evidence of the existence of interactions, but additional analytic techniques are needed to address the strength and nature of the effect (Jaccard et al., 1990).

There are several probing procedures for interactions, but the simple slope analysis is most widely used (Bauer and Curran, 2005). In this procedure, the slope and intercept are calculated for specific intervals of the moderator variable. Moderator variable values at the 1st, 50th, and 99th percentile of the observed data are used to represent low, medium, and high values, allowing examination of the statistical significance of the interaction at the complete range of scale values.

This analysis uses the regression coefficients from the above analysis which is based on the reference group of machinery plants in the United States for the country and industry control indicators. The choice of reference group only impacts the intercept, not the regression coefficients. It also assumes the mean level of the continuous control variables of plant size and process type and any other significant independent variables. Since centered data were used in the analysis, this zeros out all the variables and leaves just the examination of the interaction terms of interest.

The basic regression equation for the simple intercept/simple slope analysis resembles:

$$\hat{Y} = b_0 + b_1 X + b_2 Z + b_3 XZ$$

Where,

b_0 = regression constant

b_1 = regression coefficient for the independent variable

b_2 = regression coefficient for the moderator variable

b_3 = regression coefficient for the interaction term

So, Z equals *competitive intensity*, $\hat{Y}$ equals *innovation* or *efficiency performance*, and X equals *process improvement* or *process control* depending on which interaction is investigated. For the simple slope analysis, the regression equation is re-arranged as:

$$\hat{Y} = (b_0 + b_2 Z) + (b_1 + b_3 Z) X$$

The simple intercept equals $(b_0 + b_2 Z)$ and the simple slope equals $(b_1 + b_3 Z)$. Z values at the 1st, 50th, and 99th percentile (3.87, 5.75, and 6.77, respectively) are substituted into the equation.

Three simple slopes and intercepts are calculated for each significant interaction. A computational tool developed by Preacher et al. (2006) is used to compute and test the significance of the slopes using a t-statistic. Using the asymptotic covariance/variance matrix of the beta coefficients, the standard error is calculated for the simple slope.

The standard error of the simple slope is:

$$standard\ error\ of\ simple\ slope = \sqrt{s_{11} + 2Zs_{13} + Z^2 s_{33}}$$

Where,

s_{11} = variance of b_1

s_{13} = covariance between b_1 and b_3

s_{33} = variance of b_3

The t-statistic is calculated as:

$$t = \frac{simple\ slope}{standard\ error\ of\ simple\ slope}$$

The first set of post-hoc analyses is for the significant interaction of competitive intensity with process improvement and its relationship with efficiency. So, in that case, $\hat{Y}$ equals *efficiency performance* and X equals *process improvement*. The second and third set of analyses is for the interaction of competitive intensity with process control and competitive intensity with process improvement and its relationship with innovation, respectively. The results are listed in Table 4-4. Likewise, conditional effect plots graphically illustrate these results in Figures 4-2, 4-3, and 4-4.

Table 4-4: Results of simple slope analysis

	Y=efficiency, X=process improvement				Y=innovation, X=process control				Y=innovation, X=process improvement			
	simple slope	SE	t	p	simple slope	SE	t	p	simple slope	SE	t	p
Low competitive intensity (1st percentile)	0.490	0.221	2.217	0.027	-0.730	0.327	-2.235	0.027	0.561	0.282	1.991	0.048
Medium competitive intensity (50th percentile)	0.665	0.322	2.065	0.040	-1.050	0.479	-2.193	0.030	0.804	0.409	1.965	0.051
High competitive intensity (99th percentile)	0.760	0.377	2.016	0.045	-1.223	0.562	-2.176	0.031	0.935	0.479	1.952	0.053

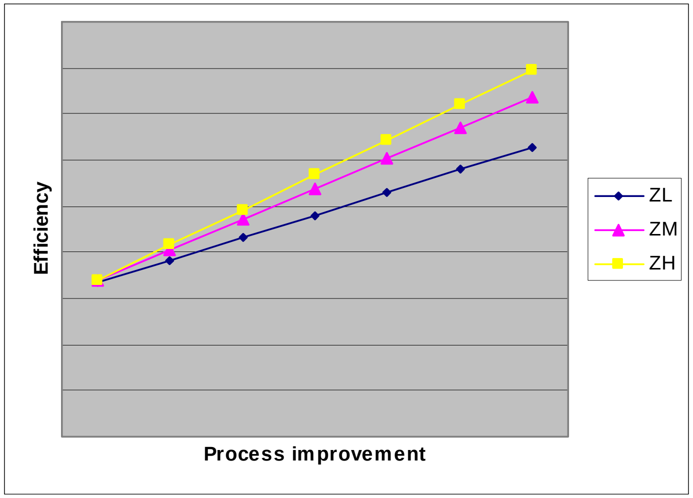

Figure 4-2: Conditional effects plot for process improvement and efficiency

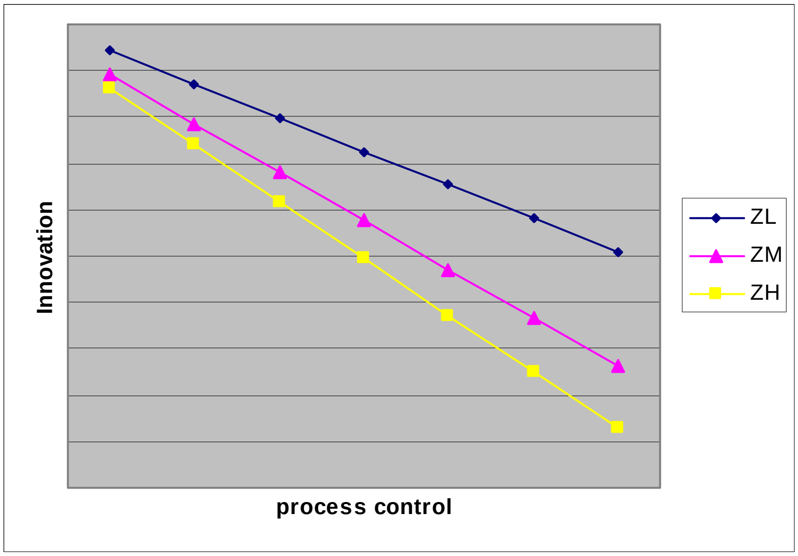

Figure 4-3: Conditional effects plots for process control and innovation

Figure 4-4: Conditional effects plot for process improvement and innovation

Probing the impact of competitive intensity on the relationship between process improvement and efficiency shows that, at each level (low, medium, and high), the regression coefficient is statistically significant at $p \leq 0.05$. Likewise, analyses show that the interaction of competitive intensity with process control is statistically significant ($p \leq 0.05$) for Z_L, Z_M, and Z_H. As the moderator variable moves from low to high, the regression coefficient becomes more negative. This supports the earlier finding that process control has a greater negative impact on innovation as competitive intensity increases.

Interestingly the correlation between process improvement and innovation moves from significant ($p \leq 0.05$) to non-significant ($p > 0.05$) as competitive intensity increases. At low levels of competitive intensity, there is a significant positive relationship between process improvement and innovation. However, at the medium and high levels of competitive intensity, the relationship become less statistical significant and can be considered insignificant at the 0.05 level. In this situation, another method called the "regions of significance" can provide additional information as to "over what range of the moderator the effect of the focal predictor is significantly positive" (Bauer and Curran, 2005). First developed by Johnson and Newman (1936), a region of significance procedure identifies the moderator values at a selected statistical criteria level of α. Choosing α of 0.05 and using Preacher et al. (2006), it is determined that, inside the region of Z equal to 1.65 and 5.1, there is a significant positive relationship between process improvement and innovation. Moderation by competitive intensity is not significant outside of this range on the 1-7 Likert scale. Table 4-5 provides a summary of the outcomes of the tested hypotheses.

Table 4-5: Summary of tested hypotheses

	Hypothesis	Result
H1	Process control is positively related to efficiency	Not supported
H2	**Process improvement is positively related to efficiency**	**Supported**
H3	**Process design is positively related to efficiency**	**Supported**
H4	Process control is negatively related to innovation	Not Supported
H5	Process improvement is positively related to innovation	Not Supported
H6	**Process design is positively related to innovation**	**Supported**
H7	Competitive intensity positively moderates control and efficiency	Not Supported
H8	**Competitive intensity positively moderates improvement and efficiency**	**Supported**
H9	Competitive intensity positively moderates design and efficiency	Not Supported
H10	**Competitive intensity negatively moderates control and innovation**	**Supported**
H11	**Competitive intensity positively moderates improvement and innovation**	**Partially Supported**
H12	Competitive intensity positively moderates design and innovation	Not Supported

4.5 Discussion

The objective of this study was to examine the impact competitive intensity has on the relationship between the elements of process management and plant level efficiency and innovation performance. The results indicate that process control is not related to competitive efficiency performance. These findings are similar to prior studies that also found no significant relationship between process control practices and operational performance (Nair, 2006; Samson and Terziovski, 1999; Powell, 1995). This does not provide any indication that process control is not critical to operational performance; it is more likely that process control is a necessary condition for operations. Evans and Lindsay (2005) noted that process control is an essential element to have in place prior to improving and re-designing processes. Process control is the foundational piece to overall process management making it a necessary for plants, yet it is not enough to provide a competitive advantage.

Process design is positively related to efficiency performance. Oftentimes plants decide to design new processes with the aim of become more efficient. This can be triggered by competition, advances in technology, or problems with the current process. Additionally, when new products are introduced, "design for manufacturing requirements in terms of labor-cost reduction through increase automation and other labor-saving opportunities" are investigated during the process design phase (Hill, 2000). The intensity of competition does not significantly alter the relationship between process design and efficiency performance, giving support for the notion that this element of process management is universally beneficial, regardless of competitive forces.

Process improvement is also related to efficiency performance. When competitive intensity increases, process improvement has a greater impact on efficiency performance. It is not surprising that, as competition becomes more intense, process improvement has a greater impact on efficiency. In competitive environments, organizations are forced to compete on the dimensions of cost, quality, and delivery (Ward and Duray, 2000). To be competitive, they must be able to manage their cost, improve their quality, and/or deliver product to the market quickly and on-time. Incremental changes can keep an organization competitive (Benson et al., 1991). Continuous improvement of processes is vital to beating the competition on these performance dimensions (Flynn et al., 1995).

With regard to innovation, process design efforts are positively related to innovation performance, in spite of the level of competitive pressure. The success of new products can be affected by the design of the manufacturing process. Over time, more organizations are moving to concurrent engineering, where new products and processes are designed simultaneously (Koufteros et al., 2001). Process design draws on higher levels of learning that require exploration to create the new processes that may go along with the new products. Effective process design will aid in getting higher quality products to the market faster, resulting in an advantage over the competition (Hill, 2000).

Process control was found to have a more negative impact on innovation performance as the level of competition increases. Trying to maintain existing processes in a highly competitive environment can result in decreased innovation performance. In rapidly changing environments, time spent maintaining processes is not advantageous. Organizations that spend a lot of time on process control are weakened because they are maintaining processes that will soon be outdated, instead of developing new processes that will keep them competitive.

Under low to moderate levels of competitive intensity, process improvement has a positive effect on innovation performance. This is interesting because it suggests that process improvement can improve innovation performance in environments in which competitive pressures are present but not at extremely high levels of competitive intensity. Consequently, under fierce competition, process improvement does not significantly influence innovation performance. This finding partially supports prior management literature that suggests that process improvement hinders a firm's ability to focus on innovation through exploration (Benner and Tushman; 2003). One explanation for this finding may be that, at low levels of competitive intensity, more incremental innovation occurs. This type of innovation can benefit from process improvement, since it places more attention on exploiting the existing processes. However, at high levels of competitive intensity, organizations are often forced to compete with new products and processes introduced by others in the industry. This may spark more radical innovation within the organization. In this context, as the dynamics of the market rapidly change, organizations may need to implement newer processes. Plants in an intensively competitive environment should focus more on process design, which will impact innovation performance.

4.6 Conclusion

4.6.1 Research contribution

The main contribution of this essay is the examination of process management as a multidimensional phenomenon that can have differing effects on performance, depending on the level of competitive intensity. Scholars have discussed process management as consisting of distinct elements (Juran and Godfrey, 1999; Silver, 2004; Hammer, 2002), but this is one of the first studies to empirically examine process management in this fashion. Previous studies utilized a single construct or multiple manufacturing practices such as customer/supplier involvement, statistical quality control, process focus, and cross functional teams. Using this measurement approach demonstrates how process management can influence both efficiency and innovation. In addition, this study provides further insight into the paradoxical outcomes of previous studies. The inclusion of competitive intensity as a contingency variable helps to explain when the elements of process management significantly impact efficiency and innovation.

Even though there may appear to be a conflict between innovation and efficiency, plants can pursue both performance goals (Kotha and Swamidass, 2000). The findings support the perspective that process management can be tailored to achieve a certain type of performance (Sutcliffe et al., 2000). When process management is broken down into the components of design, control, and improvement, organizations do not have to sacrifice innovation performance. Instead, they simply need to shift their emphasis among the three dimensions to focus more on process design and less on process control and improvement, depending on their environment's level of competitive intensity. This work provides empirical support for the notion that process management is beneficial for organizations that encounter the more flexible situations often associated with innovative organizations. Although process control can hinder innovation, it is the design of new processes and the improvement of existing processes that give the plant the ability to be effective at efficiency and innovation. Organizations like Motorola are now confirming that process management and innovation can co-exist in the same organization (Crockett, 2006).

4.6.2 Practical implications

In addition to the research contributions, this study has practical implications. Process design is becoming increasingly important for plants that focus on new product development and innovation. As firms engage in activities like concurrent engineering, a process management program that focuses on process design, such as Design for Six Sigma, can support these efforts. But the key insight from this study is that process management can be an effective tool if the levels of process design, control, and improvement are a fit with the competitive environment. In terms of today's process management programs like Six Sigma (which focuses on process improvement and process control) and Design for Six Sigma (which focuses on process design), the two programs can coexist in a healthy fashion in a plant. With process management, organizations do not have to sacrifice innovation performance. Levels of process design, control, and improvement can be customized to enhance innovation or efficiency performance, which is an important aspect of managerial decision-making.

4.7 Limitations and future research

There are several limitations associated with this study that can generate exciting future research opportunities. First, our analysis uses only perceptual measures of performance. Ketokivi and Schroeder (2004a) showed that perceptual measures were valid proxies for objective measures, but objective measures are relatively free from measurement error (Devaraj et al., 2001). Subsequent studies could include objective measures for innovation and efficiency performance.

Second, this study uses cross-sectional data. It is probable that the introduction of a new process or process improvement does not immediately result in better efficiency (Repenning and Sterman, 2002). The delay due to learning or noise from process disruption may not diminish for some time (Adler and Clark, 1991). A longitudinal study would be able to monitor the effects of process management on efficiency over a period of time.

Additionally, the environment was proposed as a moderating variable using contingency theory. Contingency theory is based on the concept of fit, and there are many types of fit that can be tested (Venkatraman, 1989). Although the model tested in this study is warranted, alternate models of moderation and mediation should be explored. For example, environmental characteristics may not only moderate the relationship between practices and performances, but also drive practices. Strategic and structural variables may have a similar relationship (Ketokivi and Schroeder, 2004b).

Finally, this study does not distinguish the type of competitive environment. For example, using Porter's (1980) conceptualization of strategic focus, one could position Wal-Mart and UPS in low-cost competitive environments, where Motorola and 3M are in differentiation-focused competitive environments. These may impact the level of process design, process control, and process improvement. Future research should consider exploring the mediating and/or moderating role of organizational structure, plant level strategy, and other aspects of environmental dynamism. Through these additional studies, researchers can provide managers with more information on the appropriate management initiatives to advance under various organizational contexts.

In spite of these limitations, this research study has established that elements of process management have a diverse impact on efficiency and innovation performance. More importantly, it shows that organizational context does play a role in the effectiveness of process management. Using process design, control, and improvement as a means to study process management is a significant contribution to the literature. With this approach, additional research can be performed that may provide more valuable insights on process management and its relationship to other operations management concepts.

Appendix 4-1: Independent measures

Please indicate the extent to which you agree or disagree with each of the following statements about this plant and organization: 1-strongly disagree, 2-disagree, 3-slightly disagree, 4-neutral, 5-slightly agree, 6-agree, 7 strongly agree

	Factor Loadings
Process Design	
Our processes are effectively developed and implemented	**.717**
We pay close attention to the organization and skill changes needed for new processes	**.840**
We strive to be highly responsive to our customers needs	**.504**
Processes in our plant are designed to be "foolproof"	**.498**
Process Control	
A large percent of the processes on the shop floor are currently under statistical quality control	**.881**
We use charts to determine whether our manufacturing processes are in control	**.816**
We monitor our processes using statistical process control	**.870**
Charts plotting the frequency of machine breakdowns are posted on the shop floor	**.612**
Information on quality performance is readily available to employees	**.650**
Process Improvement	
We strive to continually improve all aspects of products and processes, rather than taking a static approach	**.696**
We believe that improvement of a process is never complete; there is always room for more incremental improvement	**.559**
Problem solving teams have helped improve manufacturing processes at this plant.	**.687**
Management takes all product and process improvement suggestions seriously	**.445**
Competitive Intensity	
We are in a highly competitive industry	**.827**
Our competitive pressures are extremely high	**.773**
We don't pay much attention to our competitors (reverse)	**.608**
Competitive moves in our market are slow and deliberate, with long time gaps between companies' reactions (reverse)	**.695**

Appendix 4-2: Dependent measures

Indicate how your plant compares to its competition in your industry, on a global basis:
1 – poor, low end of industry, 2 – Equivalent to competition, 3- Average, 4- Better than average, 5- Superior

	Factor Loadings
Efficiency Performance	
Unit cost of manufacturing	**0.623**
*Conformance to product specifications	
On time delivery performance	**0.589**
Inventory turnover	**0.838**
Cycle time (from raw materials to delivery)	**0.794**
Innovation Performance	
Speed of new product introduction into the plant	**0.843**
On time new product launch	**0.749**
Product innovativeness	**0.826**

* Item was delete

Chapter 5

Conclusion

The goal of this dissertation was to examine process management and the contextual factors that influence its relationship with performance. This was accomplished with three separate essays. In the first essay, a measurement instrument for process management was developed and validated. The second essay focused on the internal context of the organization, testing the linkages between organizational culture, process management, and operational performance. The final essay examined the fit of process management with external competitive pressures and its relationship with innovation and efficiency performance. In each essay, the contribution to research and practice, as well as limitations and future research directions, were discussed in regards to that particular study. The remaining parts of this conclusion section will center on linking the academic and practical implications of all three studies and discussing the overall limitations of this dissertation and avenues for future research.

5.1 Contribution to academic literature

This dissertation is the start of new approach for empirically examining process management. One of the significant contributions of this research is the development of a more comprehensive and differentiated view of measuring process management. Previous measures of process management that used a single construct or set of tools and techniques provided a good start to investigating this phenomenon (ref. Table 2-1), but, to start to resolve the conflicts associated with process management, a new measurement approach was needed. An interesting finding from the first essay is that process design, process improvement, and process control are three distinct elements and, for statistical analysis, should not be combined to represent a higher order factor of process management.

This study also confirms that the organizational context must be considered when studying the effectiveness of process management. Several researchers have argued this perspective (Sutcliffe et al., 2000; Nair, 2006), yet few have empirically tested it (Sousa and Voss, 2001). The findings in the second and third essays yield a consistent message that organizational context, whether internal or external, is essential to gauging the effect of process management on performance.

When viewed as separate constructs, interesting results occurred. From the last two studies, it is evident that process control is a necessary dimension of process management, but it does not lead to high performance. This provides additional support for previous studies that have found similar results.

An additional contribution of this dissertation to academic literature is its finding that there are different cultural values that fit with process design, process improvement, and process control. This is exciting, as it helps to explain the complexities associated with implementing process management. Seemingly, the degree of competitive intensity can also help to explain the difficulty of ascertaining the effectiveness of process management illustrated in prior research. The link between process improvement and process design with efficiency performance is intuitive. However, this dissertation provides evidence that these same elements of process management are also useful in attaining high innovation performance.

5.2 Contribution to practice

Not only useful for academics, this dissertation has some significant implications for practice. Practitioner oriented publications like the *Wall Street Journal* and *Business Week* have written numerous articles on process management programs. Some articles focus on the principal difficulties associated with process management (White, 2005). It is apparent from these articles that consideration of the organizational context is vital to implementing and maintaining a successful process management program.

As the competitive landscape changes, the importance of management practices will change with it. Managers should pay attention to this when considering which practices to implement. For those who are striving to achieve innovation and efficiency performance, process management can be a useful program so long as it is configured to match the environment. Process management can help managers balance the maintenance of existing process with the implementation of new processes. Managers can choose the tools and techniques within the dimensions of process management that are going to best help them achieve the type of balance needed to compete in their environment. This study contributes to practice by providing a guide as to which elements managers should concentrate on given their operating environment.

This dissertation can also serve as a management reference for the type of organizational culture that enables each aspect of process management. Implementing process design, process control, and process improvement practices forces organizations to balance cultural values of flexibility and stability with internal and external orientations. Managers should pay attention to the internal organizational context of their firm's organizational culture, since tools are not enough to achieve high performance (Powell, 1995; Liker, 2004).

5.3 Limitations and future research

There are some limitations associated with this dissertation that can trigger interesting future research. These limitations can be segregated into measurement limitations, data limitations, and limitations associated with theory.

With respect to measurement, this study views process management as three elements of process control, process improvement, and process design that can range from incremental to radical. However, process improvement and process design may be able to be decomposed even further. This study does not consider the full spectrum of improvement and design. Future research should continue this work and investigate radical versus incremental change and development.

Additionally, this dissertation uses cross-sectional data from manufacturing plants, which is not generalizable beyond a manufacturing setting. Extending these studies to other operational settings can yield a fruitful research stream, which can be further enhanced with the inclusion of longitudinal studies.

Finally, from a theory perspective, future research should clarify how contextual variables impact the configuration of process management elements (i.e., the level of use). For example, in environments such as the pharmaceutical industry, there may be less effort geared toward process improvement and more emphasis on process control and process design. The strict regulatory nature of the industry makes it difficult to change processes once implemented, and it is crucial to have many process control procedures in place to maintain the safety and efficacy of manufactured product. In this illustration, a contextual variable may impact how the elements of process management are configured for a specific environment. Conversely, contextual variables may influence the effectiveness of process management, as illustrated in the third essay. Clarifying mediation and moderating relationships will be a significant contribution to theory and practice.

With the addition of these three studies to the body of literature on process management, there is still much more to be discovered. Process management is a core concept within the operations and supply chain management fields; nevertheless, there are avenues in process management and organizational context that have yet to be investigated (Nair, 2006; Sousa and Voss, 2001). Opportunities to research various internal and external contextual variables and their impact on the configuration and effectiveness of process management can provide beneficial information for research and practice alike.

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