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The Effect Of Organizational Knowledge Creation On Firm Performance: An Operational Capabilities-Mediated Model

BY

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ACCEPTANCE

This dissertation was prepared under the direction of Michael Jordan's dissertation committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Executive Doctorate in Business in the J. Mack Robinson College of Business of Georgia State University.

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ABBREVIATIONS

List of Abbreviations (in Alphabetical Order)

DCA — Dynamic Capabilities
JIT — Just-in-Time
KBT — Knowledge-based Theory of the Firm
RBT — Resource-based Theory of the Firm
TKC — The Dynamic Theory of Knowledge Creation
TQM — Total Quality Management

ABSTRACT

The Effect Of Organizational Knowledge Creation On Firm Performance: An Operational Capabilities-Mediated Model

BY

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4/19/2012

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What operational factors can explain the performance differences between manufacturing firms? Scholars have produced a significant volume of research that examines the linkages between operational factors (resources and practices) and firm performance. There is agreement that organizational capabilities mediate the relationship between operational factors and firm performance. However, due to the numerous and sometimes contradictory definitions of organizational capabilities in the literature and because organizational capabilities includes non-operational factors, it has been suggested that operational capabilities, as a sub construct of organizational capabilities, is more appropriate for establishing an empirical relationship between operational factors and firm performance. Scholars have argued that process improvement practices facilitate the development of operational capabilities, which can consequently lead to improved firm performance. Other scholars have argued that process improvement practices facilitate organizational knowledge creation, which can also influence firm performance. We integrate these two theoretical perspectives into a single conceptual model that better explains the relationship between knowledge-creating practices and firm operational performance. Specifically, we argue that knowledge-creating practices play a significant role in developing a firm's operational capabilities, which in turn, influence firm operational performance. This research investigates the existence of a relationship between organizational knowledge creation and firm operational performance that is mediated by operational capabilities.

CHAPTER 1

INTRODUCTION

1.1 Background and Problem Statement

In the 1980s Toyota Motor Company began flooding the U.S. market with automobiles that were low cost, high quality, and trendy. The big five automobile manufacturers were caught off guard by this move. The question for them was — how could Toyota produce such quality cars and then sell them at a price significantly lower than American-made cars and still make a reasonable profit? The initial conclusion by the American car industry was that Toyota was trying to “buy the market,” a strategy that intentionally loses money in order to gain market share. With such a strategy, once market share is established the price would gradually increase. However, over several years, Toyota did not increase its prices. To the continued dismay of the American automobile industry, Toyota introduced more low cost models and gained a significant position in the U.S. automobile market. This was the great “wake up call” for the American car market and by implication, all American manufacturing firms.

In response to this, several influential books were published in the early 1980s on the topic of Quality Management (Quality) by W. Edwards Deming, Joseph Juran and others giving birth to Total Quality Management (TQM). Shortly thereafter, Bill Smith and team at Motorola developed a statistical-based improvement system called Six Sigma in 1986 giving birth to process management — extending TQM even further. It was the general consensus that Toyota developed unique competitive advantages by developing their own “flavor” of TQM practices. Therefore, the assumption was that firms practicing TQM would develop the same capabilities as Toyota over time.

In the late 1980's, the Massachusetts Institute of Technology (MIT) formed an academic research unit for the purpose of studying Toyota to ascertain how the firm was able to out perform American carmakers, results of which were published in the 1990 book "The Machine that Changed the World." According to the authors, Toyota had developed a new kind of production system that Toyota referred to as "Just-in-time" (JIT) that enabled the company to produce automobiles faster, cheaper, and better than their American competitors. JIT was more than just a few manufacturing innovations, but in fact was fueled by an intricate system of continuous process improvement that was pervasive throughout the entire company (Womack, Jones, & Roos, 1990). A later book, "Lean Thinking," explicated a new system called "Lean Manufacturing" which adapted Toyota's JIT system for American manufacturers (Womack & Jones, 1996). From this point forward, companies all over the world began to adopt process improvement in its many forms.

The assumption behind the practice of process improvement is that it can improve a company's operational performance, that is, the capability of a company to perform relative to its competitors on operational measures of success (Peng, Schroeder, & Shah, 2008; K. C. Tan, Kannan, Jayaram, & Narasimhan, 2004). Operational performance, in turn, affects the financial measures of business success such as profitability, growth, and market share. However, with twenty plus years of process improvement history on record, it has been widely reported that as many as 80% of process improvement initiatives fail to produce expected business results (Blanchard, 2006). As a result, executives are widely divided as to whether their firms should embrace process improvement. Even the advocates of process improvement cannot clearly articulate all of the causal mechanisms by which process improvement promotes firm performance (Swink, Narasimhan, & Kim, 2005). Thus, a key question is – why do so many process improvement initiatives fail to achieve business results? Are these failures the result of things that firms are not doing at all or not doing well enough? A better understanding of the causal links between process improvement activities and firm performance will shed some light on these questions.

Conceptual models have been developed that link process improvement to business performance, but such models all contain some assumptions and therefore reflect a degree of causal ambiguity (Linderman, Schroeder, & Sanders, 2010). There is a general consensus among practitioners that process improvement can lead to improved operations performance as reflected in lower inventories and lower cycle times and that such operational efficiencies can enhance certain firm performance measures (A. S. Choo, Linderman, & Schroeder, 2007). However, there is also wide agreement among scholars that such operational efficiencies are necessary but are not sufficient to explain the performance differences among firms (Mukherjee & Lapre, 1998).

A more recent stream of thinking concerns the relationship between organizational knowledge and firm performance. It is widely observed that we are living in a "knowledge society" (Bell, 1973; Drucker, 1995; Toffler, 1990) and that firms employ “knowledge workers”. There have been many influential publications that argue the acquisition and use of organizational knowledge plays a major role in the firm performance of firms (Davenport & Prusak, 1998; Ikujiro Nonaka & Takeuchi, 1995; Senge, 1990; Toffler, 1990). This has resulted in a major shift in both strategic management and operations management thinking regarding what gives firms competitive advantage. In the 1980’s and 1990’s, Michael Porter’s Five Forces framework for competitive advantages and threats dominated strategic management practice and theory. Due to the emergence of organizational knowledge as a critical factor in how firms achieve competitive advantage, conceptual models of firm performance have shifted in the direction of core competencies, dynamic capabilities, organizational capabilities, and organizational learning, emphasizing the role of organizational knowledge as a major factor in firm performance.

Influential authors writing about quality management and process improvement (Deming, Juran, Senge, Womack and Jones) emphasize the importance of organizational knowledge for achieving continuous process improvement (Linderman, Schroeder, Zaheer, Liedtke, & Choo, 2004). One scenario is that firms will implement occasional process improvements that achieve only temporary and marginal enhancements to specific operational measures. Such process improvements do not happen frequently enough to affect operational capabilities. To achieve continuous process improvement over the long term (like Toyota) requires the mobilization and application of organizational knowledge for the purpose of developing key organizational capabilities that can lead to firm performance. That is, the creation and use of organizational knowledge is a key factor if process improvements are to be conducted pervasively, continuously, effectively, and sustainably (Anand, Ward, Tatikonda, & Schilling, 2009; A. S. Choo, et al., 2007; Linderman, et al., 2010; Ikujiro Nonaka, von Krogh, & Voelpel, 2006). Indeed, it is generally accepted that "ad hoc" process improvements driven primarily by structured method "tools" without concern for the role of organizational knowledge deliver limited operational performance results (Anand, Ward, & Tatikonda, 2010; Mukherjee & Lapre, 1998; Tsai & Li, 2007). As years of evidence indicate, such limited operational efficiencies are not sufficient to achieve sustained firm performance (Li, Huang, & Tsai, 2009; Ikujiro Nonaka, et al., 2006).

The current question is — what role does organizational knowledge play in the long term success of process improvement initiatives (i.e., like Toyota) and consequently how does this organizational knowledge influence the performance of firms? Practitioners and academics alike have been struggling to answer this question and it is this question that motivates this research. The answer to this question is essential to explain the performance variance among firms from both an operations management and strategic management perspective.

1.2 Study Motivation and Guiding Research Questions

Although scholars have proposed different models and frameworks to explain the performance differences between firms, it is generally agreed that a firm can outperform competitors if it can achieve sustainable operational advantages relative to its rivals (J. B. Barney & Clark, 2007). The two dimensions of firm performance relevant to this study are operational performance and financial performance. Financial performance is reflected in measures such as return on total assets, profitability, sales growth rate, and market share (K. C. Tan, et al., 2004). If a firm can consistently do better on these performance measures than many of its competitors, then the firm has achieved a degree of sustainable competitive advantage (J. B. Barney & Clark, 2007). There is also wide agreement among scholars that operational performance can be a source of competitive advantage (K. C. Tan, et al., 2004; Wu, Melnyk, & Flynn, 2010). Operational performance is commonly measured by manufacturing cost performance, delivery performance, flexibility, and product quality (Tan, Kannan, & Narasimhan, 2007). Thus, there is a consensus that operational performance is a strong predictor of financial performance (Wu, et al., 2010). Therefore, we use the term "firm performance" in this study to describe how well a firm consistently does on operational performance measures which can influence financial measures relative to competitors. Both operational and financial performance indicators reflect the degree of competitive advantage that a firm has achieved (Wu, et al., 2010). Further, it is assumed that the greater the performance of a firm, the more efficient and effective the firm is at creating value relative to its competitors (Peng, et al., 2008).

Scholars in the disciplines of strategic management and operations management have produced a significant volume of research that examines the linkages between operational factors (resources and practices) and firm performance. As a way to explicate these linkages, both disciplines have converged on organizational capabilities as a mediating factor. Much of the research in this area is informed by the Resource-based Theory of the firm (RBT), a theoretical framework for explaining the sources and sustainability of firm performance (J. Barney, 1991; Grant, 1991). RBT argues that when a firm acquires and uses resources in an inimitable way it can achieve a degree of competitive advantage which, in turn, can improve firm performance. Firms that achieve superior performance have specialized assets embedded with firm knowledge and skills making such assets difficult for competitors to imitate. According to RBT, both knowledge and practices can be considered types of firm resources (J. Barney, 1991; Grant, 1991; Peteraf, 1993). The RBT further argues that organizational capabilities are important to achieving firm performance because such capabilities enables a firm to efficiently and effectively create value for customers — the source of a firm's profits (Colotla, Yongjiang, & Gregory, 2003).

Both strategic management and operations management literature streams suggest that there is a relationship between a firm's resources and the development of organizational capabilities. However, each literature stream has an overlapping and somewhat different view as to the nature of this relationship. The strategic management literature generally views organizational capabilities as being developed by the interaction of firm resources where such resources can be reconfigured to respond to threats and opportunities in the market (Amit & Schoemaker, 1993; Eisenhardt & Martin, 2000; Lee & Kelley, 2008; Peng, et al., 2008). The operations management literature views organizational capabilities as a collection of practices where such practices utilize clusters of resources to achieve desired outcomes (Peng, et al., 2008; Tan, et al., 2007).

Establishing an empirical link between operational factors, organizational capabilities, and firm performance is challenging because organizational capabilities is a broad construct that is defined in many different ways in the literature (Wu, et al., 2010). For example, some scholars define organizational capabilities as a second-order construct that develops from the interaction of a firm's resources (Amit & Schoemaker, 1993). Others define organizational capabilities as a collection of practices (Dosi, Nelson, & Winter, 2000; Peng, et al., 2008). Still others define organizational capabilities in terms of competences which confer competitive advantages to firms (Prahalad & Hamel, 1993) where a competence is a "bundle of aptitudes, skills, and technologies that the firm performs better than its competitors, that is difficult to imitate and provides an advantage in the marketplace" (Coates & McDermott, 2002, p. 436). The literature on organizational capabilities is "riddled with inconsistencies, overlapping definitions and outright contradictions" (Zahra, Sapienza, & Davidsson, 2006, p. 917). For example, organizational capabilities are sometimes used in such a way that it overlaps, is interchangeable with, or includes other related constructs such as resources and practices (Wu, et al., 2010).

For these reasons organizational capabilities can be problematic for conducting empirical research on the relationship between operational practices and firm performance (Wu, et al., 2010). It has been suggested that operational capabilities is a sub-construct of organizational capabilities and is more appropriate for establishing an empirical relationship between operational practices and firm performance (Tan, et al., 2007; Wu, et al., 2010). Wu (2010) establishes clear boundaries that differentiate operational capabilities from the related construct of operational practices and develops six reflective indicators of operational capabilities – 1) operational improvement, 2) operational innovation, 3) operational customization, 4) operational cooperation, 5) operational responsiveness, and 6) operational reconfiguration. Wu (2010) argues that the six indicators of operational capabilities emerge from the interaction between a firm's resources, operational practices and social network (the informal interactions among employees). As Wu (2010) states, "operational capabilities provide unity, integration, and direction to resources and operational practices. They encapsulate both explicit elements (e.g., resources, practices) and tacit elements (e.g., know-how, skill sets, leadership) for handling a variety of problems or dealing with uncertainty" (p. 726). Further, "operational capabilities draw on resources and operational practices to generate outcomes consistent with desired results" (p 726). Thus, "Operational capabilities are firm-specific sets of skills, processes, and routines, developed within the operations management system, that are regularly used in solving its problems through configuring its operational resources" (Wu, et al., 2010, p. 726). Wu (2010) posits that operational capabilities "are the 'secret ingredient' in explaining the development and maintenance of competitive advantage".

Tan (2004) found that certain process improvement practices develop operational capabilities, which in turn leads to enhanced operational performance. Tan (2004) and Tan (2007) found empirical support that "there are three critical elements of operational capability – new product design and development, JIT [practices], and quality management" (Tan, et al., 2007, p. 5139). Further, "operational capability is the result of a strategic commitment to new product development, quality-improvement and waste elimination strategies such as just-in-time" (Tan, et al., 2007, p. 5136). Tan (2007) concludes that when a firm focuses on product and process improvements it increases its operational capabilities resulting in firm performance advantages along the dimensions of cost, quality, delivery, and flexibility (Tan, et al., 2007).

Consistent with Tan (2007), Peng (2008) also investigated the link between operational practices and operational capabilities. The researchers posit, “an operational capability is the strength or proficiency of a bundle of interrelated routines for performing specific tasks” (Peng, et al., 2008, p. 734). The study found empirical support that practices relating to continuous process improvement, process management, and quality management leadership develop operational capabilities that result in firm performance gains.

To summarize, Wu (2010) operationalizes the construct of operational capabilities and differentiates it from the related construct of operational practices. Tan (2007) empirically established that operational practices relating to process improvement and quality management build operational capabilities that lead to firm performance. Consistent with Tan (2007), Peng (2008) also established that bundles of practices relating to process improvement build operational capabilities that result in firm performance. Thus, it has been empirically established in the literature that process improvement practices can develop operational capabilities that lead to increased firm performance. This is consistent with the RBT perspective that argues an increase in operational capabilities can result in an increase in firm performance (Barney 1991; Grant 1991; Peteraf, 1993). Thus, operational capabilities can be an effective way to link process improvement practices and firm performance.

It has been widely acknowledged by scholars that even though many firms imitate the process improvement practices of high-performing firms like Toyota, these firms fail to achieve any significant improvements to operational capabilities and subsequently firm performance (Cepeda & Vera, 2007; Schroeder, Bates, & Junttila, 2002; Shah & Ward, 2003; S. Spear & Bowen, 1999; Wu, et al., 2010). This empirical data is at odds with the conclusions of Tan (2004, 2007) and Peng (2008) that suggest process improvement practices can positively influence firm performance via operational capabilities. The performance variance among these firms suggests that there is more going on between operational practices and operational capabilities than has been discussed in the literature. Tan (2004, 2007) and Peng (2008) posit a direct causal link between process improvement practices and operational capabilities. But, if this were true it would be expected that companies adopting Toyota's process improvement practices would develop the requisite operational capabilities that would translate to improved firm performance. However, this does not always happen. This variance elicits questions such as, "Do all process improvement practices build operational capabilities or do specific practices build these capabilities?" and "Are there sequences or interactions between process improvement practices that have a more potent effect on operational capabilities?"

In another stream of literature, researchers have investigated the relationship between process improvement practices and organizational knowledge creation. One of the first studies to investigate this relationship was Mukherjee (1998) who found that certain process improvement practices facilitate organizational learning. The study distinguishes between two types of learning —conceptual learning (know why) and operational learning (know how). The researchers posit that certain process improvement practices promote conceptual learning while other practices promote operational learning. The study concludes that both types of learning play a critical role in the creation of organizational knowledge.

Building on Mukherjee (1998), subsequent studies have adopted the dynamic theory of organizational knowledge creation as a means to explain the relationship between process improvement practices and organizational knowledge creation. Nonaka (1994) argues that organizational knowledge is created through a continuous interaction between tacit and explicit knowledge. Four modes of knowledge conversion (socialization, combination, externalization, internalization) function as the basic "mechanisms" of knowledge creation. Although new knowledge initially originates within individuals via these interactions, the knowledge is then further refined and amplified throughout the organization creating a "knowledge spiral" propelled by the organization's social network (Nonaka, 1994).

Linderman (2004) developed a theoretical framework linking specific process improvement practices and organizational knowledge creation. Informed by the dynamic theory of organizational knowledge creation, the researchers argue that certain practices create knowledge via specific modes of knowledge creation. This argument was supported in a subsequent empirical study by the same researchers where it was confirmed that process improvement practices can lead to organizational knowledge creation (Linderman, et al., 2010). Nonaka (1994) and Anand (2010) developed a theoretical model that predicts the success of process improvement projects as a function of knowledge-creating practices. Specifically, the empirical study found that the success of process improvement projects is significantly related to the use of (1) practices that capture explicit knowledge of team members and (2) practices that capture tacit knowledge of team members. The study concludes that certain process improvement practices create organizational knowledge, which positively affects the success of process improvement projects. Thus, it has been empirically established in the literature that process improvement practices engage one or more of the modes of knowledge conversion and by doing so facilitate the creation of organizational knowledge (Anand, et al., 2010; A. S. Choo, et al., 2007; Linderman, et al., 2010; Linderman, et al., 2004; Sabherwal & Becerra-Fernandez, 2003).

Researchers investigating the relationship between process improvement practices and firm performance have found it challenging to empirically establish this link because there are too many confounding factors that exist between organizational knowledge creation and firm performance. As Mukherjee (1998) explains, “field researchers must control for potentially confounding factors such as variations in product and resource markets, general management policies, corporate culture, production technology, and geographical location…or they would be hard pressed to assert with any confidence that a specific bit of knowledge had a specific impact [to firm performance]” (Mukherjee & Lapre, 1998, p. S35).

We argue that the missing piece, an area that has been overlooked in the literature, is the mechanism by which organizational knowledge creation (facilitated by process improvement practices) develops operational capabilities. It has already been established in the literature that operational capabilities can positively influence firm performance (J. Barney, 1991; Fugate, Stank, & Mentzer, 2009; Peng, et al., 2008; Tan, et al., 2007; Wu, et al., 2010). Thus, if this missing piece were explained, then it would provide a causal path between organizational knowledge creation and firm performance. Table 1-1 shows the specific gap that exists in the literature concerning the role of organizational knowledge creation in developing effective operational capabilities.

→ **TO**

	Process Improvement Practices	Organizational Knowledge Creation	Operational Capabilities	Operations Performance	Financial Performance
Process Improvement Practices		(Anand, et al., 2010; A. S. Choo, et al., 2007)	(K. C. Tan, et al., 2004)	(Cua, McKone, & Schroeder, 2001; Hallgren & Olhager, 2009)	(Fullerton & McWatters, 2001; Ittner & Larcker, 1997)
Organizational Knowledge Creation			**This Study** ***<u>No previous studies</u>**	(Carrillo & Gaimon, 2000; Fugate, et al., 2009)	(Fugate, et al., 2009; Zakuan, Yusof, Laosirihongthong, & Shaharoun, 2010)
Operational Capabilities				(Wu, et al., 2010) **This Study**	(Tan, et al., 2007)
Operational Performance					(Ward, Duray, G. Keong Leong, & Chee-Chuong, 1995) **This Study**

Table 1-1: Existing research and the gap in the literature

If a causal path exists between organizational knowledge creation (in the context of process improvement practices), operational capabilities and firm performance, this would reconcile the conclusions of Tan (2004, 2007) and Peng (2008) with the many exceptions that have been noted by scholars as to why some firms achieve improved performance via process improvement practices while many other firms implementing similar practices do not (Cepeda & Vera, 2007; Schroeder, et al., 2002; Shah & Ward, 2003; S. Spear & Bowen, 1999; Wu, et al., 2010). Stated another way, a firm may use standard process improvement practices and not achieve an increase in performance because such practices may fail to create the requisite organizational knowledge that develops operational capabilities.

The objective of this research is to investigate the existence of a positive relationship between organizational knowledge creation (via knowledge-creating practices) and firm performance with operational capabilities as the mediating factor (see Figure 1-1).

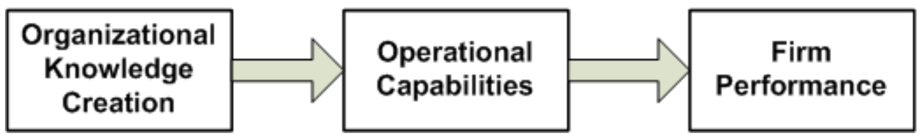

Figure 1-1: The mediated effect of knowledge creation on firm performance

In doing so, this study will contribute to theory by addressing the aforementioned gap in the literature. We use the Resource-based Theory of the firm (RBT), the Knowledge-based Theory of the firm (an extension of RBT), and the dynamic theory of organizational knowledge creation as theoretical lenses to investigate these relationships.

CHAPTER 2

LITERATURE REVIEW

The objective of this chapter is to examine and synthesize the theories, concepts and research findings that are relevant to this study. We examine the various literature streams from the perspectives of organizational knowledge creation theory, the Resource-based Theory of the firm, and the Knowledge-based Theory of the firm.

2.1 Definition of Knowledge

Some scholars have defined knowledge as “justified true belief” (Alavi & Leidner, 2001; Nonaka, 1994). Justified true belief can ‘‘enhance an entity’s capacity for effective action’’ (Sabherwal & Becerra-Fernandez, 2003, p. 227). The underlying premise of this definition is that knowledge is characterized by beliefs and commitment, where ‘‘the power of knowledge to organize, select, learn, and judge comes from values and beliefs as much as, . . . from information and logic’’ (Davenport & Prusak, 1998, p.12); they further explain that knowledge is “a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experience and information” (p. 5). According to Spender (1996) “justified true belief is the result of systematic (scientific) analysis of our sensory experience of a knowable external reality. Knowledge is tested by seeing whether it predicts our experience of that reality” (p. 47). As Nonaka (1995) states —

> *“We adopt a traditional definition of knowledge as “justified true belief.” It should be noted, however, that while traditional Western epistemology has focused on “truthfulness” as the essential attribute of knowledge, we highlight the nature of knowledge as “justified belief.” While traditional epistemology emphasizes the absolute, static, and non-human nature of knowledge, typically expressed in propositions and formal logic, we consider*

knowledge as a dynamic human process of justifying personal belief toward the truth" (Ikujiro Nonaka & Takeuchi, 1995, p. 58).

Nonaka (1994) further explains, "The status of truth is that it directs justification of belief towards experience. In other words, beliefs are true to the extent that they can be justified by the individual organizational member at certain moments and using various mental models" (I. Nonaka & von Krogh, 2009, p. 639). Alavi and Leidner (2001) argue that knowledge is meaning made by the mind and without such meaning, knowledge becomes inert, static and disorganized information. This definition of knowledge as justified true belief includes both explicit and tacit knowledge as components of knowledge (Sabherwal and Becerra-Fernandez, 2003; Davenport and Prusak, 1998; Nonaka, 1994; Polanyi, 1966). Explicit knowledge can be articulated and specified either verbally or in writing, while tacit knowledge is unarticulated, intuitive, and often cannot be verbalized (Polanyi 1966).

The definition of knowledge as justified true belief is the predominant positivist view in Western culture and a generally accepted premise in organizational theory (Nonaka & Takeuchi, 1995). However, constructivist perspectives argue that knowledge cannot be conceptualized independently from action, changing the idea that knowledge is a commodity that individuals or organizations may acquire, to the notion of knowing as something that they do (Blackler, 1995; Nicolini & Meznar, 1995; Polanyi, 1966). Cook and Brown (1999) argue that explicit and tacit knowledge is not a complete definition of knowledge; in order to explain the totality of what somebody knows, the concept of knowing must be added to the definition of knowledge; while explicit and tacit knowledge can be possessed by a person, knowing is about practice rather than something that can be possessed, thus practice is about interacting with the social and physical world where a person practices their knowing — knowledge is put into action. This is consistent with the work of Polany (1966) that posits that knowledge is an activity that is better described as a process of knowing, a position which has greatly influenced the defining of knowledge as dynamic (Crossan 2003 in Easterby-Smith & Lyles, 2003). As Easterby-Smith (2003) explains, the knowledge management literature has mostly discussed whether knowledge is a possession or whether it is embedded in practice (Orlikowski, 2002). According to Easterby-Smith (2003), "Knowledge can be understood as something that individuals, groups or organizations have (knowledge as possession); but also as something that individuals, groups and organizations do (knowledge as practice)" (Easterby-Smith & Lyles, 2003, p. 241).

2.2 Organizational Knowledge

Organizational knowledge is an established theoretical construct in the literature. It has been suggested that organizational knowledge is a key resource of the firm that promotes competitive advantage (Crossan 2003 in Easterby-Smith & Lyles, 2003). Underlying this perspective is the Resource-based Theory of the firm (J. Barney, 1991; Penrose, 1959). Several influential scholars argue for a "Knowledge-based Theory of the firm," a theoretical framework that seeks to explain how organizational knowledge provides an advantage to firms over organized markets (Ghoshal & Moran, 1996; Grant, 1996; Kogut & Zander, 1992). Organizational knowledge indicates a firm's capacity to act that differentiates it from competitors promoting competitive advantage (Leonard-Barton, 1992). Thus, organizational knowledge is the critical resource that distinguishes a firm (Kogut and Zander, 1996; Spender, 1996). Organizational knowledge is comprised of the components of both explicit and tacit knowledge as suggested in the work of Polanyi (1966); tacit knowledge can be "codified and written, and is therefore easy to articulate, capture and distribute" and tacit knowledge "is associated with personal skills and experience and is hence more difficult to articulate and distribute" (Easterby-

Smith & Prieto, 2008, p. 238). “Organizational knowledge is created through the interactions of individuals” (Grant 1996, p. 113). As Drucker (1995) explains, “organizational knowledge is essentially the understanding of cause and effect within processes inside the organization. Every firm operates on the basis of a ‘theory of the business’ which shapes an organization’s behavior, drives how decisions are made concerning what to do and defines what an organization considers to be meaningful performance results” (Drucker 1995, p. 26).

Some scholars argue that organizational knowledge is “situated” in everyday work routines rather than being something that is in the possession of individuals. Organizational knowledge is the knowledge that is shared by individuals (Nonaka 1994). Organizational knowledge is rooted in the day-to-day practices of members throughout a firm (Lave & Wenger, 1991; Orlikowski, 2002). “While most explicit knowledge and all tacit knowledge is stored within individuals, much of this knowledge is created within the firm and is firm specific” (Grant 1996, p. 111).

According to King (2003) there are three properties that define organizational knowledge (von Krogh, Roos, & Slocum, 1994). First, organizational knowledge is manifested through the perceptions of multiple “knowers” in a firm (Glazer, 1998; Orlikowski, 2002; Tsoukas, 1996). Thus, “measuring knowledge objectively or from one individual's viewpoint is inappropriate” (King 2003, p. 76). Second, organizational knowledge can be characterized by scope and context (von Krogh et al., 1994). That is, organizational knowledge can be scoped very generally (e.g., finance) or very specifically (e.g., knowledge about a project). Relating to context, organizational knowledge is embedded in a firm and grounded within the firm’s industry environment (von Krogh et al., 1994). Thus, organizational knowledge is acquired and shared within an organizational context, is embedded within the social context, and cannot be fully reduced to individuals (Foss, 1996). Third, organizational knowledge is generated and acquired through the use of language (King 2003). Individuals within organizations use language to make a distinction between knowledge that is relevant from knowledge that can be ignored (von Krogh et al., 1994). "Language, therefore, articulates the scope of what is and is not organizational knowledge" (King 2003, p. 76).

2.3 The Dynamic Theory of Organizational Knowledge Creation

Nonaka (1994) developed a comprehensive theoretical framework of organizational knowledge creation and retention called the dynamic theory of organizational knowledge creation (TKC). Nonaka (1995) argues that prior to his framework there have been few studies about how knowledge was created within an organization. Instead, the field was focused primarily on knowledge management – the acquisition, accumulation, and utilization of existing knowledge – rather than the creation of new knowledge (Nonaka, 1995). Aspects of the TKC are based on the earlier work of Polanyi (1966) that categorizes knowledge as explicit and tacit (Anand 2010). Specifically, Polanyi (1966) classified human knowledge into two categories — 1) Explicit or codified knowledge that is transmittable in formal, systematic language; 2) on the other hand, tacit knowledge has a personal or subjective quality, which makes it hard to formalize and communicate (Nonaka, 1994).

As Nonaka (1994) states, "the theory of knowledge creation embraces a continual dialogue between explicit and tacit knowledge which drives the creation of new ideas and concepts" (p. 12). Further, capturing both explicit and tacit types of knowledge conveys performance advantages to a firm (Anand, 2010). The "classification of knowledge as either explicit or tacit is a prominent classification in the knowledge-management literature (Anand 2010). The focus of TKC is on knowledge creation at the organizational level rather than the individual level. Thus, "the theory posits an ontology that recognizes the differences between individual, group, and organizational knowledge-creating entities" (Nonaka 1995, p. 57).

Knowledge creation consists of two dimensions—epistemological and ontological. Nonaka (1994) states that the epistemological dimension makes a distinction between tacit and explicit knowledge and the interaction between these two forms of knowledge. Four modes of knowledge conversion are created when tacit knowledge and explicit knowledge interact. "The four modes are socialization, combination, externalization, and internalization and together they make up the 'engine' that drives the knowledge creation process. These four modes of knowledge conversion are what individuals experience and are also the mechanisms by which knowledge is communicated and amplified throughout an organization" (Nonaka 1995. p. 13). As Nonaka (1994) further explains,

> *"Organizational knowledge is created through conversion between tacit and explicit knowledge allowing us to postulate four different "modes" of knowledge conversion: (1) from tacit knowledge to tacit knowledge, called Socialization, (2) from explicit knowledge to explicit knowledge, called Combination, (3) from tacit knowledge to explicit knowledge called Externalization, and (4) from explicit knowledge to tacit knowledge, called Internalization" (Nonaka 2004, p. 18).*

"Although ideas are formed in the minds of individuals, interaction between individuals typically plays a critical role in developing these ideas. That is to say, 'communities of interaction' contribute to the amplification and development of new knowledge" (Nonaka 1994, p. 19); and "the key to organizational knowledge creation is the mobilization and conversion of tacit knowledge" (p. 22).

According to Nonaka (1994) the ontological dimension of organizational knowledge creation involves a knowledge creation spiral that occurs when the interaction between tacit and explicit knowledge is raised from the individual level to the organizational level. The essence of the dynamic theory of organizational knowledge creation has to do with how this knowledge spiral emerges (Nonaka 1995). As Nonaka (1994) states,

> *"A 'spiral' model of knowledge creation is proposed which shows the relationship between the epistemological and ontological dimensions of knowledge creation. This spiral illustrates the creation of a new concept in terms of a continual dialogue between tacit and explicit knowledge. As the concept resonates around an expanding community of individuals, it is developed and clarified. Gradually, concepts which are thought to be of value obtain a wider currency and become crystalized" (Nonaka 1994, p. 20).*

Nonaka (1994) explains, "There are several levels of social interaction at which the knowledge created by an individual is transformed and legitimized. An informal community of social interaction provides an immediate forum for nurturing the emergent property of knowledge at each level and developing new ideas (p. 22). Further, "organizational knowledge creation, therefore, should be understood in terms of a process that 'organizationally' amplifies the knowledge created by individuals, and crystallizes it as a part of the knowledge network of organization" (Nonaka 1994, p. 20). Each of the modes of knowledge creation (knowledge modes) is discussed in detail in the following sections.

2.3.1 Socialization

Socialization is the process of creating tacit knowledge through shared experience (Nonaka 1994). Linderman (2004) states that this mode of knowledge conversion requires that individuals interact with one another, and in doing so, create tacit knowledge such as shared mental models and technical skills. The sharing of tacit knowledge through socialization can occur without using language — such is the case with mentoring, observation, imitation, and "hands on" practice. Shared experiences promote the socialization process by enabling individuals to empathize with one another and incorporate the others' feelings and beliefs about a shared experience (Linderman 2004). In the context of process improvement, "socialization practices" can be promoted by assembling cross-functional project teams that disregard hierarchical boundaries (Anand 2010). In this situation, socialization practices combine the tacit knowledge of individuals to create a common understanding among team members about the process being improved (Fiol, 1994; Weick & Roberts, 1993). Consistent with Linderman (2004), Anand (2010) finds that socialization practices enable team members to incorporate the perspectives of other team members while deliberating on process improvement opportunities, problems, and solutions.

Socialization practices enable individual team members to express their ideas to the team based on their experience and, in doing so, provides insights to problems that others team members might not have considered working in isolation (Anand 2010). Specific socialization practices include brainstorming, idea-generation, nominal group techniques, structured project facilitation methods, and root-cause problem analysis (Anand, et al., 2010; Breyfogle, 2003). According to Linderman (2010) process improvement tools and methods help facilitate an understanding of problems and their resolution. Further, establishing a common problem-solving methodology can assist team members to socially engage with each other to develop a common understanding of problems and opportunities (Linderman 2010). That is because common technical problem-solving language essentially acts as a universal translator between divergent thought worlds. The technical problem-solving language not only enables social interaction, but also promotes understanding of technical aspects of [process improvement]" (Linderman 2010, p. 690). Scholars have argued that effective discussions and interactions during problem-solving sessions can enable a team to develop a shared mindset and overcome cultural barriers and defensive routines (Schein, 1992).

2.3.2 Combination

Nonaka (1994) states that combination involves the use of social processes to combine different pieces of explicit knowledge held by individuals or information systems. Through exchange mechanisms such as meetings, telephone conversations and emails, individuals exchange and combine explicit knowledge. New knowledge can be created by repurposing and recombining existing information through the sorting, adding, re-categorizing, and re-contextualizing of explicit knowledge. Thus, combination is the process of creating explicit knowledge from explicit knowledge (Nonaka 1994). "Combination is the process of systematizing concepts and combining different bodies of explicit knowledge" (Linderman 2004, p. 595). In the context of process improvement, "combination practices" create new knowledge by making team members cognizant of the explicit relationships between process characteristics through measurement and analysis of data (Zhang, Jeen-Su, & Mei, 2004).

These practices facilitate the combining of pieces or fragments of explicit knowledge from different sources and through the reconfiguring and systematizing of the pieces; new explicit knowledge is created (Constant et al., 1996). This recombining of existing explicit knowledge can be done using specialized database applications or knowledge-sharing systems with sophisticated search capabilities (Voelpel et al. 2005). Such computer systems can help teams make sense of cause–effect relationships by combining different elements of explicit knowledge during process improvement events, thus making the explicit knowledge applicable in finding solutions to problems (Breyfogle, 2003). According to Anand (2010), "using combination practices, project team leaders can help their teams sift through explicit data, drawing explicit insights about the targeted processes" (p. 305).

2.3.3 Externalization

Externalization is the conversion of tacit knowledge into explicit knowledge (Nonaka 1994). Nonaka (1994) states that metaphor is an effective way to convert tacit knowledge into explicit knowledge and is the first step in transforming tacit knowledge into explicit knowledge. Consistent with Nonaka (1994), Linderman (2010) argues that externalization is often facilitated by metaphors, analogies, concepts, hypotheses, and models that are created by teams when they create concepts triggered by discussion and collective reflection (Linderman 2004, 2010). In the context of process improvement, "externalization practices" facilitate the explicit expression of tacit concepts and ideas in the form of language and visual schemata. These practices convert tacit knowledge held by individual members of a team into explicit forms that include numbers, written descriptions, diagrams, or pictures that facilitate group discussion and analysis (Anand, et al., 2010; Bohn, 1994; Hansen, Nohria, & Tierney, 1999).

Externalization practices "enable individuals to express, summarize, and view explicitly the knowledge they have created jointly through the exchange and synthesis of tacit knowledge, thus creating common understanding. Further, externalization practices assign explicit measurements to subjective performance attributes, thus facilitating assessment, comparison, and scientific experimentation" (Anand 2010, p. 304). Expressing tacit knowledge via externalization practices can assist a team to establish how captured explicit knowledge should be used to improve a process (Raelin, 1997). While socialization practices generally require physical proximity of team members and concurrent activities, communities of practice can effectively use externalization practices across distances (Constant, Sproull, & Kiesler, 1996; Voelpel, Dous, & Davenport, 2005). In process improvement events, externalization practices can facilitate the conversion of tacit knowledge that is difficult to codify into explicit knowledge by providing common methods and tools such as cause-and-effect diagrams, and failure modes and effects analysis charts (Anand, et al., 2010; Breyfogle, 2003; Jensen & Szulanski, 2007). Externalization practices also motivate team members to express their ideas by providing structured methods to convert such ideas into explicit form (Tucker, 2007).

2.3.4 Internalization

Internalization is the conversion of explicit knowledge into tacit knowledge; has some similarity to the traditional concept of 'learning' is deeply related to "action" (Nonaka 1994, p. 17). Linderman (2004) states, "For explicit knowledge to become tacit, it helps if the knowledge is verbalized or diagrammed into documents, manuals, or oral stories. Documentation helps individuals internalize their experiences, thus enriching their tacit knowledge" (p. 591). "In internalization, an individual absorbs tacit knowledge through demonstrations and other means" (Sabherwal & Becerra-Fernandez, 2003, p. 230). Internalization often occurs through re-experiencing what was learned, as is often the case in learning-by-doing" (Linderman 2004, p. 595). In the context of process improvement, internalization practices facilitates the conversion of explicit knowledge into tacit knowledge which can result in a common understanding among team members as to the best way to accomplish work (C. W. Choo, 1998; Grant, 1996). Internalization practices include efforts taken to understand and adopt best practices from other areas and projects within the firm (Tucker et al., 2007).

Anand (2010) argues that such practices make it possible to capture explicit knowledge and then convert the knowledge into useful forms that can be comprehended and absorbed by others working in the processes; this conversion to useful forms "is critical for the creation of team knowledge about the working of the processes being targeted for improvement" (Anand

2010, p. 306). Internalization practices also include "learning-by-doing" activities such as on-the-job training that are used to apply explicit knowledge derived from previous improvement projects (Becerra-Fernandez & Sabherwal, 2001). Becerra-Fernandez & Sabherwal (2003) argues that because explicit knowledge can be embodied in action and practice, internalization practices enable individuals to re-experience what others have gone through which then creates tacit knowledge in these individuals. Further, individuals could acquire tacit knowledge in virtual situations, either vicariously by reading or listening to other's stories, or experientially through simulations or experiments" (p. 230). Internalization practices include using control charts and error-proofing procedures (Anand 2010).

2.4 The Resource-based Theory of the Firm

The Resource-based Theory of the firm (RBT) is a widely-accepted theoretical framework for understanding how a firm achieves competitive advantage by means of its resources and capabilities (Corbett & Claridge, 2002). As Grant (1996) explains —

> *"The resource-based view of the firm is less a theory of firm structure and behavior as an attempt to explain and predict why some firms are able to establish positions of sustainable competitive advantage and, in so doing, earn superior returns. The resource-based view perceives the firm as a unique bundle of idiosyncratic resources and capabilities where the primary task of management is to maximize value through the optimal deployment of existing resources and capabilities, while developing the firm's resource base for the future" (Grant, 1996, p. 110).*

RBT emphasizes that a firm uses its organizational capabilities to achieve competitive priorities based on the assumptions that resources are heterogeneous across all firms (Coates & McDermott, 2002). To the extent that the unique combination of resources and organizational capabilities of a firm is inimitable, rare, and non-substitutable, a firm may achieve competitive advantage over its rivals (J. Barney, 1991; J. B. Barney, 1995; Dierickx & Cool, 1989). RBT argues that the transferability of a firm's resources and capabilities is a critical determinant of the firm's capacity to achieve sustainable competitive advantage (J. B. Barney, 1986). Thus, the RBT sees knowledge as an objective transferable commodity (Spender, 1996). Firms are successful because they are able to acquire and control resources in a productive way which gives the firm a sustainable source of competitive advantage that cannot easily be imitated by rivals; such inimitability is the result of a firm using proprietary process knowledge to convert resources into capabilities which is not transparent to other firms (J. Barney, 1991; Grant, 1991; Peteraf, 1993).

According to RBT, operational capabilities are significant because a firm's resources and capabilities comprise the basis of a firm's strategy and as such can be considered essential to a firm's financial success and a way to define a firm's identity (Colotla, et al., 2003). Management scholars often use RBT to understand the sources of capabilities as a way to explain the significant differences in firm performance (Peng, et al., 2008). Grant (1996) states that "if the strategically most important resource of the firm is knowledge, and if knowledge resides within individual organizational members, then the essence of organizational capability is the integration of individual's specialized knowledge" (Grant, 1996, p. 375).

2.5 The Knowledge-based Theory of the Firm

According to Grant (1996), the Knowledge-based Theory (KBT) emphasizes the firm "as an institution for the production of goods and services" and "It is the task of production through the transformation of inputs into outputs where the issues of creating, acquiring, storing and deploying knowledge are the fundamental organizational activities" (p. 120). The KBT is an outgrowth of the Resource-based Theory of the firm to the extent that it argues that knowledge is the most strategically important resource belonging to a firm (Grant, 1996; Kogut & Zander, 1992). According to Grant (1996), "fundamental to a Knowledge-based Theory of the firm is the assumption that the critical input in production and the primary source of value is knowledge…it is a Knowledge-based Theory of value on the grounds that all human productivity is knowledge dependent, and machines are simply embodiments of knowledge" (p.112).

The Knowledge-based Theory argues that knowledge can be a valuable resource that enables a firm to achieve performance advantages (Argote, McEvily, & Reagans, 2003; Kogut & Zander, 1992). As Nonaka (1995) states, "the organization that wishes to cope dynamically with the changing environment needs to be one that creates information and knowledge, not merely processes them efficiently" (p. 50). "The perspective of the knowledge-based view stresses a positive link between knowledge and performance" (Crossan 2003 in Easterby-Smith & Lyles, 2003, p. 133). Knowledge that is valuable, rare, and inimitable can lead to competitive advantage (Barney, 1991). Knowledge-creating practices contribute to the competitive performance of firms by creating new process knowledge and thereby increasing operational capabilities (Anand, et al., 2010; Shah & Ward, 2003; Zu, Fredendall, & Douglas, 2008). The Knowledge-based Theory of the firm provides a theoretical perspective in understanding how knowledge-creating practices lead to competitive performance; knowledge is a critical resource for a firm that ultimately enables the firm to achieve sustained competitive performance (Davenport & Prusak, 1998; Grant, 1996; Kogut & Zander, 1996; Spender, 1996).

2.6 Organizational Capabilities

Within the literature, there are different views on the definition of organizational capability (Lee & Kelley, 2008; Schreyögg & Kliesch-Eberl, 2007; Zahra, et al., 2006) to the point that the literature is "riddled with inconsistencies, overlapping definitions and outright contradictions" (Zahra, et al., 2006, p. 917). According to several scholars, organizational capabilities is a higher-level construct that develops from the interaction of a firm's resources

(Wu 2010). Other scholars define organizational capabilities in terms of a firm's unique strengths that confer competitive advantages to such firms (Wernerfelt, 1984). Coates & McDermott (2002) posit that organizational capabilities are "a bundle of aptitudes, skills and technologies that a firm performs better than its competitors, that is difficult to imitate and provides an advantage in the marketplace" (p. 436). A firm can intentionally develop organizational capabilities by facilitating the interaction among the firm's resources (Dierickx & Cool, 1989; Amit & Schoemaker, 1993), which are integrated within the firm's idiosyncratic social network (Schreyogg & Kliesch-Eberl, 2007). According to Grant (1996), organizational capability is the outcome of knowledge integration; and the linkage between organizational capability and competitive advantage is mediated by this knowledge integration. Further, "The extent to which a capability is 'distinctive' depends upon the firm accessing and integrating the specialized knowledge of its employees" (Grant 1996, p. 116).

There are numerous studies in the strategic management literature that define organizational capabilities as bundles of routines that are distinct and also interrelated (Amit & Schoemaker, 1993; Henderson & Cockburn, 1994; Hult, Ketchen Jr, & Nichols Jr, 2003; Prahalad & Hamel, 1990; Stalk, Evans, & Shulman, 1992). The complex nature of the interrelated routines makes organizational capabilities difficult to see much less to be imitated by a firm's competitors (Tanriverdi & Venkatraman, 2005). An organizational capability is the "strength or proficiency of a bundle of interrelated routines for performing specific tasks" (Peng 2008, p. 736). Organizational capabilities can be generally classified into two groups — capabilities that enable a firm to conduct basic functional activities and capabilities that enable a firm to improve and renew existing activities (Collis, 1994; Henderson & Cockburn, 1994).

Summarizing from the literature, organizational capabilities are higher-order constructs that emerge from the interaction of a firm's resources; are firm-specific and integrated within the firm's processes; are the things that a firm does well that confers strategic advantage; are embedded within the firm's social network rather than individuals; are comprised of tacit knowledge that may be taken for granted; are path dependent and affected by a firm's history and managerial decisions; and are difficult to imitate due to the covert and complex interactions with the firm's processes (Grant, 1991; Ray, Barney, & Muhanna, 2004; Teece, Pisano, & Shuen, 1997).

2.7 Operational Capabilities

Operational capabilities can be considered a sub-domain of the larger organizational capabilities construct; therefore research findings on organizational capabilities can be useful to the understanding of operational capabilities (Wu 2010). Operational capabilities have been described as operational tasks that an organization does well (Skinner, 1969), an accumulation of strategic assets that are acquired through time that are not easily copied, acquired, or substituted (Dierickx and Cool 1989), activities within a firm that an organization can do better than competitors (R. H. Hayes & Pisano, 1996), and key abilities that enable an organization to compete on certain dimensions which make a difference in the market (H. H. Safizadeh, Ritzman, & Mallick, 2000). Peng (2008) conceptualizes operational capabilities as a bundle of organizational routines where operational improvement and operational innovation are the key capabilities within a manufacturing facility (Peng 2008). Operations capabilities have also been characterized as competitive priorities (Tan 2007). Some have suggested that new operational capabilities are a function of the output of dynamic capabilities (Cepeda 2007). Tan (2004) proposes a three-factor model that examines how organizations acquire operations capability.

Specifically, the study posits that the acquisition of operations capability is a function of an organization's commitment to the principles of quality management and to process improvement practices. The results provided strong support for these two propositions. According to Tan (2007) —

> *"We posit that operations capability is the result of a strategic commitment to new product development, quality-improvement and waste elimination strategies such as just-in-time (JIT). Excellence on dimensions of performance such as cost, quality, delivery, and flexibility is the result of systems that focus organizational resources on product and process improvements"*
> *(Tan, et al., 2007, p. 5136).*

According to Wu (2010) operations strategy, and to a large extent strategic management, is centered on three concepts: operational capabilities, operational practices, and firm resources. Because these are closely-related concepts, there is a tendency to confuse them. Wu (2010) offers a concise definition of operational capabilities that integrates operational practices and firm resources into a single definition —

> "*Operational capabilities provide unity, integration, and direction to resources and operational practices. They encapsulate both explicit elements (e.g., resources, practices) and tacit elements (e.g., know-how, skill sets, leadership) for handling a variety of problems or dealing with uncertainty. That is, operational capabilities draw on resources and operational practices to generate outcomes consistent with desired results, helping a plant develop solutions that make sense. Based on the perspectives of organizational capabilities in the strategic management literature, we apply their essential traits to the functional domain of operations management, offering the following definition: Operational capabilities are firm-specific sets of skills, processes, and routines, developed within the operations management system, that are regularly used in solving its problems through configuring its operational resources" (Wu, et al., 2010, p. 744).*

Wu (2010) posits that operational capabilities do not stand out within a firm because they are an integral part of the organizational system making them essentially invisible to workers, managers, and researchers. Operational capabilities are deeply embedded in a firm's operating and management systems as the result of the "interconnectness of operational capabilities with resources and operational practices, linkages between operations capabilities and the social network, and the fit with the primary problems that the firm and its operations management address" (Wu 2010, p. 742).

Operational capabilities contribute to competitive advantage and hence can explain much of the performance variance among different firms. However, according to the Resource-based Theory of the firm (RBT), operational capabilities are one necessary condition, but are not by themselves sufficient to create competitive advantage. Wu (2010) established that operational capabilities has high validity in predicting intermediate operational performance outcomes such as cost, quality, delivery, and flexibility — the dimensions of operational performance commonly endorsed among operations management scholars. Beyond operational performance, operational capabilities are one of the key factors along with other mediating factors that can significantly affect competitive performance (Wu 2010).

According to Wu (2010) operational capabilities is a reflective latent construct consisting six indicators. As such, co-variation among these six indicators is caused by (and therefore reflects) variation in the underlying latent factor (Jarvis, Mackenzie, Podsakoff, Mick, & Bearden, 2003; MacKenzie, Podsakoff, & Jarvis, 2005). As a latent construct, operational capabilities cannot be directly observed. Like the approach taken by Eisenhardt & Martin (2000) to measure the reflect construct of dynamic capabilities and the approach taken by Schein (2004) to measure the reflective construct of organizational culture, operational capabilities can be measured via the six reflective indicators defined by Wu (2010). It has been established that the existence of common indicators does not imply that any specific operational capability is exactly the same across firms. Although operational capabilities may be idiosyncratic to each firm, it has common attributes across firms that can be measured. By observing these visible attributes, it is possible to impute the nature of the underlying latent construct (Wu 2010). As Wu (2010) explains,

> *"When measuring operational capabilities, we should focus on their commonalities. Thus, measurement models will, by necessity, be incomplete, because we recognize that it is not possible to capture the idiosyncratic or firm-specific components of operational capabilities. When measuring commonalities, we should focus primarily on artifacts, which reflect a deeper underlying operational capability. Thus, instruments used to capture information from respondents must focus on perceptual, self-reported measures of operational capabilities" (Wu 2010, p. 733).*

Table 2-1 summarizes the initial taxonomy and origins of the six operational capabilities indicators developed by Wu (2010). In addition to drawing from the literature, Wu (2010) refined and empirically validated the resulting definitions via a focus group of experienced operations managers. In the following sections, the literature references for each of the six indicators are explicated in more detail.

Table 2-1: Origins and Definitions of Organizational Capabilities Indicators

Operational Capability Indicator	Origin	Definition
Operational Improvement	Swink & Hegarty, 1998; Peng et al., 2008	Differentiated sets of skills, processes, and routines for incrementally refining and reinforcing existing operations processes.
Operational Innovation	Swink & Hegarty, 1998; Peng et al., 2008	Differentiated sets of skills, processes, and routines for radically improving existing operations processes or creating and implementing new and unique operations processes.
Operational Customization	Wheelwright & Hayes, 1985; Schroeder et al., 2002	Differentiated sets of skills, processes, and routines for the creation of knowledge through extending and customizing operations processes and systems.
Operational Cooperation	Swink & Hegarty, 1998; Droge, Jayaram, & Vickery, 2004; Escrig-Tena & Bou-Llusar, 2005	Differentiated sets of skills, processes, and routines for creating healthy and stable relationships with people from various internal functional areas and external supply chain partners.
Operational Responsiveness	Upton, 1994; Swink & Hegarty, 1998	Differentiated sets of skills, processes, and routines for reacting quickly and easily to changes in inputs or output requirements.
Operational Reconfiguration	Teece et al., 1997; Swink & Hegarty, 1998; Pandza et al., 2003a	Differentiated sets of skills, processes, and routines for accomplishing the necessary transformation to re-establish the fit between operations strategy and the market environment, when their equilibrium has been disturbed.

Source: Table adapted from Wu (2010), p731.

2.7.1 Operational Improvement

Operational improvement is "the strength or proficiency of a bundle of interrelated organizational routines for incrementally improving existing products/processes" where the objective is creating small wins that add up to superior competitive performance (Peng 2008, p. 735). Schroeder et al. (1989) suggest that operational improvement "includes implementation of new ideas or changes, both large and small, which have the potential to contribute to organizational objectives. However, managing small-scale, incremental changes requires considerably different processes and resource configurations" (Schroeder et al., 1989, p. 56). Swink & Hegarty (1998) argue that improvement capability includes three interrelated elements: 1) learning, 2) waste reduction, and 3) motivation, where learning is the ability to continually acquire and apply process knowledge, waste reduction is the ability to continuously eliminate wasteful activities within a firm's processes, and motivation is the ability to encourage and influence employees to achieve higher levels of performance (Swink & Hegarty 1998). Operational improvement consistently develops new methods of working for customers by applying the firm's technical capabilities to improve its processes (Benner & Tushman, 2003). Therefore, continuous improvement capability is a firm's ability to consistently improve its' processes by mean of small, incremental steps (Ittner & Larcker, 1997). Davenport (1995) states that "quality management, often referred to as total quality management (TQM) or continuous improvement, refers to programs and initiatives that emphasize incremental improvement in work processes and outputs over an open-ended period of time" (Davenport 1995, p. 58).

Continuous improvement "is defined as a systematic effort to seek out and apply new ways of doing work i.e. actively and repeatedly making process improvements" (Anand 2009, p. 445). Firms utilize methodologies such as Lean management and Six Sigma to achieve continuous improvement capability (Voss, 2005). While operations management executives acknowledge that it is important to continually improving processes, it can be a daunting task to manage continuous improvement initiatives (Kiernan, 1996; Pullin, 2005). It has been argued by

Linderman (2010) that operational improvement capability is related to competitive performance of a firm. The focus of operational improvements is often on immediate and measurable benefits (Harrington & Mathers, 1997; Mukherjee & Lapre, 1998), however, small improvements that are consistently implemented over time can add up conveying significant benefits the a firm with respect to quality of existing and future products (Wheelwright & Hayes, 1985). Scholars often use the terms ‘‘exploitation and exploration’’ in the management literature to make the distinction between ‘‘incremental and radical changes’’ to a firm’s processes or technology; exploitation is characterized by the gradual refinement of processes creating efficiencies within the firm (Peng 2008). Process improvement practices and process management make changes to existing process to increase efficiency which is consistent with an exploitation strategy but such practices do not necessarily motivate explorative or radical innovation within the firm (Benner and Tushman, 2003).

2.7.2 Operational Innovation

While operational improvement is defined to be continuous incremental improvement of a firm’s processes, operational innovation is about radically improving a firm’s existing processes or creating new processes (Wu 2010). Operational innovation refers to the ability of a manufacturing firm to radically improve its’ performance by creating and implementing new resources, methods, or technologies (Schroeder et al., 1989). According to Davenport (1995) radical process improvement is the same concept as process re-engineering. As Davenport (1995) explains, “reengineering, also known as business process redesign or process innovation, refers to discrete initiatives that are intended to achieve radically redesigned and improved work processes in a bounded time frame” (p. 58). Innovation means to introduce something new; as such process innovation is distinguished from process improvement because it seeks a new process design rather than incrementally improving an existing process (Davenport, 1993). According to Hammer and Champy (1993) process reengineering is “the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed” (p. 32); and Radical process change can also mean “disregarding all existing structures and procedures and inventing completely new ways of accomplishing work” (Hammer & Champy, 1993, p. 33). “Reengineering seeks radical change and dramatic improvements. It is not an incremental approach, and it is not satisfied to tinker with existing processes” (Robey, Wishart, & Rodriguez-Diaz, 1995, p. 24).

Operational innovation is the same concept as process innovation or radical process improvement applied to a firm’s operations (Wu 2010). Operational improvement is unlikely to lead to innovations that depart significantly from existing organizational competencies because it builds on existing organizational capabilities (Sitkin & Stickel, 1996 in Kramer & Tyler, 1996). Operational innovation, on the other hand, promotes experimentation with the intention of creating process variance as a means to drive organizational performance (Benner & Tushman, 2003). Operational innovation occurs via radical process change on a large scale that involves new knowledge or the significant departure from existing skills (Benner & Tushman, 2003). As such, operational innovation is accomplished using different resources, skills, and operational practices than required for incremental process improvement (Peng et al., 2008). Operational innovation involves the use of employee skills and organizational routines relating to search, discovery, and experimentation that characterize “exploration” behavior (Benner & Tushman, 2003). The strength, quality, and interrelatedness of certain bundles of organizational routines determines a firm's innovation capability for developing new products and processes (Peng 2008).

2.7.3 Operational Customization

Operational customization has its roots in the work of Wheelwright & Hayes (1985) where they argue that the development of proprietary processes will promote competitive advantage. They posit a four-stage model of manufacturing in which the most advanced stage (stage 4) is characterized by proprietary processes as one of its elements which promotes competitive advantage for a manufacturing firm. Thus, Wheelwright & Hayes (1985) provide a theoretical linkage between the development of proprietary process and competitive manufacturing performance. Further, they describe the development of proprietary processes within a manufacturing firm as an acid test to determine if the firm has achieved world-class operations. A manufacturing firm benefits from the development of proprietary process in two ways — 1) the customized processes are difficult to imitate by competitors and 2) the resulting organizational knowledge that is created during the development of such customized processes gives the firm advantages over its' suppliers which means that such knowledge is proprietary to the firm and could yield competitive advantage (Wheelwright & Hayes, 1985).

Schroeder (2002) argues that greater proprietary process leads to higher competitive performance in manufacturing. They found that the operational capabilities that result from the development of proprietary processes can lead to organizational learning that is firm-specific and path-dependent; such learning can lead to competitive advantage. There are a variety of operational practices associated with developing proprietary processes, however, different practices are associated with underlying knowledge that enables a firm to customize its processes to meet the unique needs of customers (Schroeder, et al., 2002). The capabilities that result from situated learning can result in a firm developing idiosyncratic manufacturing processes that yield competitive advantage (St. John & Harrison, 1999). As Wu (2010) explains "operational customization is differentiated sets of skills, processes, and routines for the creation of knowledge through extending and customizing operations processes and systems" (p. 728).

2.7.4 Operational Cooperation

Swink and Hegarty (1998) propose a framework that explains how growth in manufacturing effectiveness is enabled by operational integration, where integration "is the ability to easily expand an operation to incorporate a wider range of products or process technologies" (p. 5); integration is a firm's ability to coordinate between the manufacturing process and product–process design functions; they posit that a firm's proficiency at introducing custom products or processes within existing operations significantly enhances the firm's ability to meet market needs that are unique (Swink and Hegarty 1998). Using the "integration" concept from Swink and Hegarty (1998) as a starting point, Wu (2010) states that the integration concept:

> *"Is part of a broader operational capability that we call operational cooperation, which includes the ability to create and sustain healthy relationships with supply chain members, related to sourcing products. Operational cooperation is the ability to bring involved parties together to share information, converging on a shared interpretation of what needs to be done. As uncertainty increases, the need for operational cooperation capability increases, to help firms cope with the fuzziness of their environments and enact a shared vision, in order to acquire information, share views, interpret the task environment, resolve cross-functional or inter-organizational conflicts, and reach a mutual understanding of a task" (Wu et al., 2010, p. 729).*

According to Wu (2010), the rationale for "operational cooperation" is informed by information processing theory (Flynn & Flynn, 1999; Galbraith, 1973), which deals with the mechanisms that enable firms to cope with the complexities of competing in a global marketplace involving the use of advanced technologies. As Wu (2010) explains,

> *"Sources of complexity include goal diversity (variety of products, markets served, individual product volumes) (Bozarth, Warsing, Flynn, & Flynn, 2009), customer diversity (size of customer base, characteristics of customer relationships, volumes purchased by various classes of customers, distance to customers) (Anderson & Narus, 1998), supplier diversity (number of suppliers, nature of the relationship with specific suppliers, location of suppliers) (Landry, 1998; Gonzalez-Benito, 2007; Koufteros, Cheng, & Lai, 2007; Holweg & Pil, 2008; Narasimhan & Talluri, 2009), labor diversity (number of job classifications, employee layoffs), and manufacturing diversity (shifts in monthly sales, prevalence of expediting, number of levels in the bill of materials). In response to this increasing complexity and equivocality, firms seek coordinating mechanisms (Koufteros, Vonderembase, & Doll, 2002; Bozarth et al., 2009), which allow them to process more information and to do so quickly" (Wu et al., 2010, p. 729).*

2.7.5 Operational Responsiveness

Swink (2005) argues that cost efficiency and flexibility are two primary dimensions of manufacturing capability. They define flexibility as "the demonstrated ability to adapt or change plant-level operations with relatively little time or cost penalties" (p. 449). Upton (1994) posits that the manifestation of flexibility is characterized by range, uniformity of performance, or mobility of operations. There is a consensus among several scholars that there are two types of operational flexibility — process flexibility and new product flexibility (Dean Jr & Snell, 1996; M. H. Safizadeh & Ritzman, 1996; Suarez, Cusumano, & Fine, 1996; D. Upton, 1996; D. M. Upton, 1995). An empirical study by Flynn, Schroeder, and Flynn (1999) found that quality management practices were positively associated with cost efficiency and flexibility. According to Swink (2005) workforce development practices are significantly associated with process flexibility; and "improved problem-solving capabilities, along with technical and cross-training elements of workforce development programs are likely to increase worker flexibility, which in turn increases process flexibility in terms of how worker capacity is allocated, what range of activities can be done, and how quickly new activities can be learned" (Swink 2005, p. 446). Sánchez & Pérez (2005) argue that that there are different dimensions of flexibility "such as functional aspects (flexibility in operations, marketing, logistics), hierarchical aspects (flexibility at shop, plant or company level), measurement aspects (focused on global flexibility measures versus context specific ones), strategic aspects (centered on the strategic relevance of flexibility), time horizon aspects (long-term versus short-term flexibility), and object of change (flexibility of product, mix, volume)" (Sánchez & Pérez, 2005).

According to Wu (2010) "operational flexibility" is the same concept as "operational responsiveness". Thus, "operational responsiveness is the differentiated skills, processes, and routines for reacting quickly and easily to changes in input and output requirements, so that a process can consistently meet customer requirements with little time or cost penalty" (Wu 2010, p. 729). Operational responsiveness enables a firm to "manage production resources such as machine, labor, materials handling, and production sequencing in light of uncertainty" (Wu 2010, p. 729). As an organizational capability, operational responsiveness is similar to technological and production knowledge within the operations system (Q. Zhang, Vonderembse, & Lim, 2003). Thus, Wu (2010) argues that this capability which provides the foundation for flexibility performance; and "specifically, operational responsiveness allows a plant to operate at various batch sizes or produce at different production output levels (i.e., volume flexibility), based on differentiated skills, processes and routines for flattening a firm's cost curve over a wide range of production volumes" (Wu et al., 2010, p. 729). Thus, "operational responsiveness enables a firm to produce both the volume and the kinds of products that customers want, in a timely manner" (Wu et al., 2010 p. 729).

2.7.6 Operational Reconfiguration

While operational responsiveness is about using existing processes and resources to accomplish internal operational changes, operational reconfiguration "focuses on reshaping (investing and divesting) operations resources to catch up with environmental changes"; and "operational reconfiguration is based on the concept of dynamic capabilities (DCA) (Wu et al., 2010, p.730). Teece (1997) posits that dynamic capabilities are a "firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (p. 516); and "the term 'dynamic' refers to the capacity to renew competences so as to achieve congruence with the changing business environment" (p.515); "the term 'capabilities' emphasizes the key role of strategic management in appropriately adapting, integrating, and reconfiguring internal and external organizational skills, resources, and functional competences to match the requirements of a changing environment" (Teece 1997, p. 515). DCA extends the Resource-based Theory of the organization (RBT), "an influential theoretical framework for understanding how competitive advantage within firms is achieved and how that advantage might be sustained over time" (Eisenhardt 2000, p. 1105). RBT posits that organizations can be conceptualized as bundles of resources, and that those resources are heterogeneous across firms persisting over time (Eisenhardt & Martin 2000).

DCA extends RBT to dynamic markets (Teece et al., 1997). "The rationale is that RBT has not adequately explained how and why certain firms have competitive advantage in situations of rapid and unpredictable change" (Eisenhardt & Martin 2000, p. 1106). Specifically, RBT is characterized by the enduring performance variances among firms as a result of differences in resources and productivities, while DCA focuses on the ability of firms to accumulate, implement, renew, and reconfigure its' resources in order to cope with changes in the external business environment (Pandza et al., 2003). Dynamic capabilities is described as "the firm's processes that use resources—specifically the processes to integrate, reconfigure, gain, and release resources—to match and even create market change" (Eisenhardt & Martin, 2000, p. 1107). Thus, dynamic capabilities enable firms achieve "new resource conditions as markets emerge, collide, split, evolve, and die" (Wu et al., 2010, p.730).

According to Wu (2010), "dynamic capabilities" is the same concept as "operational configuration". Thus, Operational reconfiguration involves unique organizational knowledge, skills, processes, and routines necessary to re-establish a fit between a firm's operations strategy, resources and the external market environment, when a firm is faced with a rapidly changing situation in the market (Teece et al., 1997). "Operations reconfiguration evolves from routines that sense unexpected changes, maintain flexible responses, and implement synchronized operations" (Wu 2010, p. 730). Operational reconfiguration enables a firm to acquire both tangible and intangible resources as a way to deal with the different possibilities in a rapidly changing business environment, so that it can make different decisions based on new information that is learned (Pandza et al. 2003). Thus, operational reconfiguration allows a firm to quickly adapt its manufacturing strategy in response to market changes such as demand level, global competition, rapid technology advancements, and sudden changing patterns in demographics (Swafford, Ghosh, & Murthy, 2006). "Operational reconfiguration is important in uncertain and volatile business environments, where firms face new innovations, economic crises, production losses, political events, and so forth, such that the ability to sense and deal with change becomes a way of life" (Wu et al., 2010, p. 730).

2.8 JIT, Lean, and Continuous Improvement

This research involves manufacturing firms that use “Lean” as a process improvement approach in order to enhance operational capabilities. Like other process improvement systems, the desired outcome of using Lean is to improve product/service quality, reduce operating costs, and reduce total process lead times. For the purposes of this research, we explicate the Lean improvement system so that we may later identify and classify Lean practices. Lean is essentially an adaptation of “just-in-time” (JIT), a manufacturing approach pioneered by Toyota in Japan after World War II. Womack and Jones (1990) published the book, “The Machine That Changed the World” where they first described Toyota’s JIT approach. The book laid the foundation for what they called “Lean production” which encapsulated JIT while adding additional concepts and elements. Thus, it can be said that Lean is the offspring and evolution of JIT.

Like JIT, Lean promotes the idea that continuously and incrementally improving a firm’s value-creating processes creates an improvement spiral where the operational gains have an exponential effect rather than a cumulative effect on operations capability. Although the term “continuous improvement” is not exclusive to Lean, the term is more commonly associated with the Lean improvement system because it emphasizes continuous incremental improvement. “Continuous improvement refers to sustained incremental improvements of existing products/processes” (Peng 2008, p736). Continuous improvement focuses on existing products and processes and creates small wins that collectively lead to superior operational performance (Bessant & Francis, 1999; Cole, 2002). As Anand (2010) explains, “continuous improvement is defined as a systematic effort to seek out and apply new ways of doing work i.e. actively and repeatedly making process improvements” (p.444). For firms embracing the continuous improvement approach, enhancing existing products and processes is viewed as a moving target where the firm is constantly searching for improvement opportunities (Peng 2008). Incremental improvement includes activities that modify and refine existing products, equipment, and processes (Jayanthyi & Sinha, 1998). Through their relentless pursuit of continuous improvement, many Japanese firms develop operational capabilities that lead to competitive performance (Robert H. Hayes & Wheelwright, 1984; Womack, et al., 1990).

Lean initiatives yield reductions in inventory and increased inventory turnover, improved product quality, and throughput (Fullerton & McWatters, 2001; Nakamura, Sakakibara, & Schroeder, 1998). As Tan (2007) states, "to the extent that JIT capability is a reflection of an orientation towards leanness, it demonstrates that leanness is an important aspect of operations capability" (p. 5140); and "JIT is based on the notion that simplifying manufacturing processes and reducing variation can result in the elimination of waste" (Tan 2004, p. 5141). As a frequently cited source of competitive advantage in operations, the Lean production system consists of multiple processes in production, quality management, preventive maintenance, and human resource management (Shah and Ward, 2003). According to Tan (2004), "Just-in-time capability can be operationalized in terms of an organization's commitment to reducing set-up times and lot sizes, increasing delivery frequencies, reducing inventory to expose manufacturing and scheduling problems and to free up capital, and maintaining process integrity by way of preventative maintenance" (p. 838). As Silver (2004) explains, "In manufacturing the just-in-time (JIT) revolution was based on a process improvement philosophy, i.e., changing what were taken as givens in manufacturing (e.g., long or costly setup times, long lead times, poor initial quality, and so on), rather than optimizing inventory levels, production scheduling, and so on subject to the givens" (p274).

2.9 Process Improvement Practices

Process improvement initiatives use multiple practices that involve methods characterized by sequences of steps for managing improvement events, and sets of tools and techniques for executing improvement activities (Handel & Gittleman, 2004; Pil & Macduffie, 1996). "Process improvement projects involve the use of tools and techniques—project execution practices—to harness the knowledge of team members for specific objectives" (Anand 2010, p. 305). To promote rational decision making, process improvement practices use various decision-making tools and methods (Daft & Dryden, 2000). As Anand (2010) explains, "Practices are the tools and techniques used during the implementation of process improvement projects" (p. 305). Operational practices are standardized activities, methods, or procedures that have been developed for the purpose of achieving specific operational goals or objectives (Flynn et al., 1995). Process improvement practices are expected to improve operational efficiency by improving manufacturing yields, reducing waste, and at the same time improving quality to increase customer satisfaction (Sterman & Repenning, 1997; Wruck & Jensen, 1994). Process improvement techniques enable firms to achieve faster times to market for new products and to respond quickly to environmental change (Pande, Neuman, & Cavanagh, 2000).

According to Monden (1984) JIT practices are based on the Toyota Production System. These practices include process simplification and standardization, efficient material and information flow, setup time and cycle time reduction, preventive maintenance of machines, improved product quality, and the organizational commitment to continuous improvement. In his seminal work that investigated process improvement practices and knowledge creation, Mukherjee (1998) lists a number of practices associated with process improvement efforts that include idea generation/brainstorming, data analysis, process mapping, and team problem solving. Anand (2010) investigated the effect that knowledge-creation practices have on the success of process improvement project. Specifically, the study examined the use of knowledge-creating practices by ad hoc process improvement teams to achieve desired project outcomes. The study found that knowledge-creation practices that capture both explicit and tacit knowledge contribute significantly to project success. Anand (2010) concludes, "knowledge creation is an appropriate lens in which to study the effectiveness of process improvement projects" (p. 304). Mukherjee (1998) conducted a longitudinal case study where 62 process improvement projects were examined within a manufacturing firm over the period of ten years. Consistent with Anand (2010) the study found that process improvement practices facilitate organizational knowledge creation, which, in turn, determines organizational performance.

Process improvement practices can result in the creation of organizational knowledge through formal problem-solving approaches that facilitate rational decision making (Cyert & March, 1963; Nelson & Winter, 1982). Using the dynamic theory of organizational knowledge creation (Nonaka, 1994), Linderman (2004) explored the underlying processes that facilitate organizational knowledge creation and found that process improvement practices support these processes. Using problem-solving practices, new knowledge is created when a problem is identified and then a new solution to the problem is discovered (Nickerson & Zenger, 2004). During process improvement events, a number of practices are often used to capture explicit and tacit knowledge of team members in order to achieve specific outcomes (Anand 2010). Process improvement practices such as skill development, mentoring, and reward systems lead to the development of performance capabilities (Easterby-Smith & Prieto, 2008).

2.10 Firm Operational Performance

Operational performance can be defined as "the output or result achieved due to unique operational capabilities" (Tan, et al., 2007, p. 5137). There is theoretical support in the literature that indicates the importance of cost, quality, flexibility, and delivery as indicators of firm operational performance (Cua, et al., 2001; Devaraj, Hollingworth, & Schroeder, 2004; Miller & Roth, 1994; Schroeder, et al., 2002; Ward, et al., 1995). Consistent with the literature, the researchers found that the overall operational performance measures that best differentiated high and low performing firms were — product quality performance, manufacturing cost performance, delivery performance, production flexibility performance (Cua, et al., 2001). Miller (1994) also concluded that the cost, quality, delivery, and flexibility were the key operational performance outcomes that differentiate operational capabilities of different firms. Devaraj (2004) investigated the link between manufacturing strategy and its effect upon operational performance where cost, quality, delivery, and flexibility were determined to be the best overall measures of operational performance. Tan (2007) concluded, "excellence on dimensions of performance such as cost, quality, delivery, and flexibility is the result of systems that focus organizational resources on product and process improvements" (Tan, et al., 2007, p. 5136).

CHAPTER 3

CONCEPTUAL MODEL AND HYPOTHESES

This chapter presents the conceptual model and hypotheses. A conceptual model is defined that incorporates all of the constructs and sub constructs. Formal hypotheses that specify expected relationships are developed.

3.1 Conceptual Model

The objective of this research is to investigate the existence of a positive relationship between organizational knowledge creation (via process improvement practices) and firm operational performance. As represented in the conceptual model, we posit that operational capabilities mediates the relationship between organizational knowledge creation and firm operational performance (see Figure 3-1). Informed by both RBT and KBT, we argue for a mediated relationship because organizational knowledge is a resource for value creation rather than a business outcome (J. B. Barney, 1986; Grant, 1991; Spender, 1996). It is the basic function of a firm to convert its resources into value that can be sold to customers at a price greater than the cost to create the value (Peteraf, 1993). Resources, both tangible and intangible, are inputs into the value creation process where certain operational capabilities are a requisite for creating value (Grant, 1996; Schroeder, et al., 2002; Spender, 1996). Thus, for organizational knowledge to significantly influence firm operational performance, organizational knowledge must first be converted to operational capabilities (J. B. Barney, 1986; Grant, 1991; Ray, et al., 2004). It has been established that operational capabilities is a strong predictor of financial performance (Peng, et al., 2008; Tan, et al., 2007; Wu, et al., 2010). Thus, it is reasonable to assume that the influence of organizational knowledge creation on firm operational capabilities is mediated by operational capabilities.

There is support in the literature for the mediating role of operational capabilities. Wu (2010) suggests that the way a firm's resources are used to achieve superior operational performance is mediated by operational capabilities. That is, operational capabilities is the "missing ingredient" in explaining the performance differences among firms (Wu 2010). KBT maintains that knowledge is a unique and valuable firm resource that can lead to the development of operational capabilities. To the extent that such operational capabilities can be turned into value that cannot be easily replicated by competitors, it can lead to superior firm performance (Grant, 1996; Spender, 1996; Spender & Grant, 1996).

There is support in the literature that knowledge-creating practices can influence operational capabilities. According to Dosi (2000) operational practices are the building blocks of operational capabilities and individual skills are the building blocks of the practices. As such, skills are learned from experience in a specific organizational context. Other studies have also confirmed that process improvement practices can develop operational capabilities (Anand, et al., 2010; Peng, et al., 2008; Tan, et al., 2007). According to Linderman (2004) "Nonaka's dynamic theory of organizational knowledge creation can be useful in linking process improvement practices to knowledge since it considers both tacit and explicit knowledge" (Linderman, et al., 2004, p. 447). The dynamic theory of organizational knowledge creation provides a rationale for the use of knowledge creating practices to generate organizational knowledge by engaging individual team members in process improvement projects (Anand 2010). If organizational knowledge creation, as a second-order construct, can influence operational capabilities, then we reason that each of the four modes of knowledge creation as first-order factors will also positively influence operational capabilities.

It has been established in the literature that operational capabilities can positively influence firm operational performance (J. Barney, 1991; Fugate, et al., 2009; Peng, et al., 2008; Tan, et al., 2007; Wu, et al., 2010), which is also consistent with the RBT perspective (Barney 1991; Grant 1991; Peteraf, 1993). Thus, it is reasonable to hypothesize that operational capabilities can be an effective way to link process improvement practices and firm performance. This hypothesis is supported by the KBT that posits continually creating organizational knowledge is the basis for achieving sustained firm performance relative to competitors (Spender, 1996; Linderman 2010). According to Kogut (1992), "Firms are repositories of capabilities, as determined by the social knowledge embedded in enduring individual relationships structured by organizing principles." As well, firms can translate process knowledge into unique operational capabilities that create superior competitive advantage (Kogut & Zander, 1992, p. 396). Similarly, other scholars have argued that organizational knowledge can influence firm performance via a firm's capabilities (Argote et al. 2003; Davenport and Prusak, 1998; Grant, 1996). According to (Nonaka, et al., 2006) the dynamic theory of knowledge creation explains the performance difference among firms and, in doing so, provides the building blocks for KBT to better explain the relationship between organizational knowledge creation and firm performance.

In the conceptual model, organizational knowledge creation is conceptualized as a second-order factor that contains within it four first-order factors – the modes of knowledge creation (Nonaka 2004). It has been established that process improvement practices engage one or more of the modes of knowledge creation thereby facilitating the creation of organizational knowledge (Sabherwal, 2003; Linderman, 2004; Choo, 2007; Linderman 2010, Anand, 2010). We investigate the relationship between each of the four modes of knowledge creation (as first-order factors) and operational capabilities in the context of process improvement practices. Specifically, we argue that each of the modes of knowledge creation will positively influence operational capabilities. Operational capabilities is conceptualized as a construct consisting of six reflective indicators (Wu et al., 2010). Firm operational performance is conceptualized as a second-order construct consisting of four dimensions (Schroeder, et al., 2002; Tan, et al., 2007; Wu, et al., 2010).

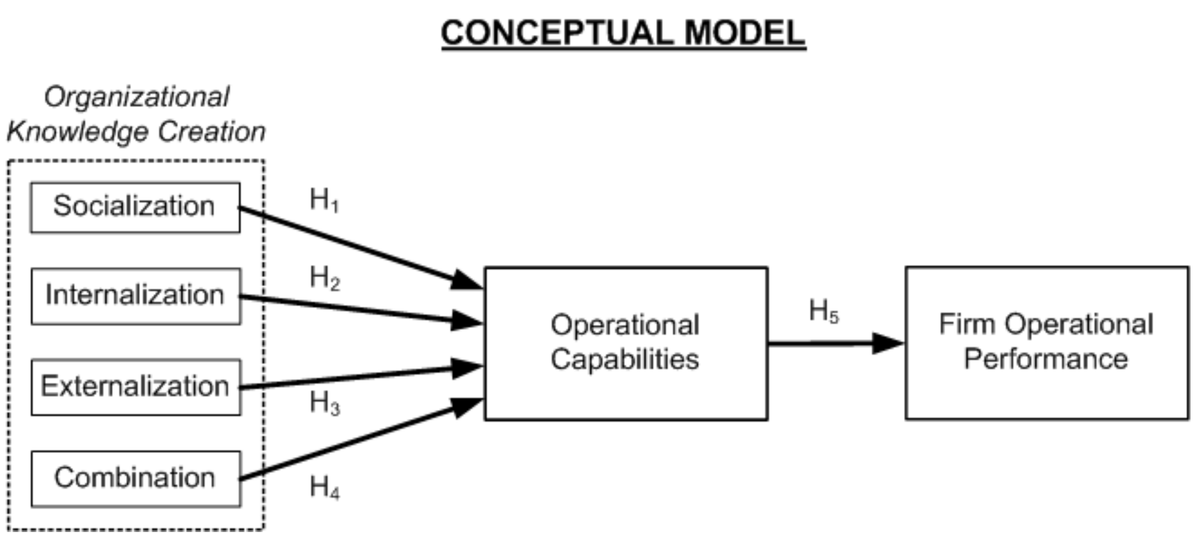

Figure 3-1: Conceptual Model

3.2 Hypothesis Development

This section formally develops the hypotheses associated with the conceptual model. We develop five hypotheses motivated by the dynamic theory of organizational knowledge creation

(TKC), the Knowledge-based Theory of the firm (KBT), the Resource-based Theory of the firm (RBT), and supporting literature.

3.2.1 Organizational Knowledge Creation and Operational Capabilities

We investigate the influence of organizational knowledge creation as a second-order factor on operational capabilities. We also investigate the influence of each of the four modes of knowledge creation on operational capabilities. In this section, we draw support from the literature and the dynamic theory of organizational knowledge creation to substantiate these claims.

Through their relentless pursuit of continuous process improvement, many Japanese firms have developed operational capabilities that lead to sustainable competitive performance (Robert H. Hayes & Wheelwright, 1984; Womack, et al., 1990). An explanation of this is provided by Anand (2010) who established that process improvement practices can create organizational knowledge by engaging the four modes of knowledge creation and that these knowledge creating practices can influence performance outcomes. As Anand (2010) explains, "Process improvement projects involve the use of tools and techniques—project execution practices—to harness the knowledge of team members for specific objectives" (Anand 2010, p. 305). Anand (2010) found that knowledge-creating practices that capture both explicit and tacit knowledge contribute significantly to desired performance outcomes. Consistent with Anand (2010), Mukherjee (1998) found that process improvement practices facilitate organizational knowledge creation, which, in turn determines organizational performance. Other scholars support these conclusions as well. Process improvement practices can result in the creation of organizational knowledge through formal problem-solving approaches that facilitate rational decision making (Cyert & March, 1963; Nelson & Winter, 1982). Using problem-solving practices, new knowledge is created when a problem is identified and then a new solution to the problem is discovered (Nickerson & Zenger, 2004).

There is wide support in the literature that the knowledge-creating properties of process improvement practices can influence operational capabilities. Tan (2004) argues that process improvement programs that have a strategic focus on the elimination of process waste promote the development of superior operational capabilities. As these process improvements are implemented, operational capabilities are developed producing results such as improvements in product quality, cost reductions, delivery lead times, and operational flexibility (Tan, et al., 2007). Over time, the development of operational capabilities via process improvement leads to superior competitive performance (Tan 2004). Consistent with Anand (2010) and Tan (2007), Wu (2010) states, "Operational capabilities provide unity, integration, and direction to resources and operational practices. They encapsulate both explicit elements (e.g., resources, practices) and tacit elements (e.g., know-how, skill sets, leadership) for handling a variety of problems or dealing with uncertainty" (p. 726).

These conclusions are consistent with what has been observed in the business community. For example, Spear (1999) and Spear (2004) conducted a four-year study of the operational practices of Toyota. They note that many companies have tried to replicate the success of Toyota by imitating the process improvement tools and practices used pervasively through the Toyota organization. As a result, the methods used in the Toyota Production System have been adapted in many industries. While many companies have achieved some operational improvements as a result of applying these methods, none of them have reached the performance level of Toyota. Scholars argue that the secret of Toyota's success lies not in the tools and practices, but rather in the operational system itself – "observers confuse the tools and practices they see on their plant visits with the system itself" (S. Spear & Bowen, 1999, p. 97). The study concluded that it is the "DNA" or operational capabilities of Toyota that is responsible for the high level performance of the firm, not solely the application of specific tools and practices (Spear 1999, Spear 2004). These conclusion are echoed by (Wu 2010) who explains,

> *"Operational capabilities are the secret ingredient that is hidden in plain view for several reasons. First, operational capabilities are not as obvious and tangible as operational practices and resources. When trying to explain success, managers tend to focus on factors that are readily perceived and relatively easy to duplicate and implement" (Wu 2010, p. 743).*

The findings of these scholars support our argument that organizational knowledge creation must first convert to operational capabilities before it can affect business outcomes. There is further support in the literature that organizational knowledge influences operational capabilities. Grant (1996) states that "if the strategically most important resource of the firm is knowledge, and if knowledge resides within individual organizational members, then the essence of organizational capability is the integration of individual's specialized knowledge" (Grant, 1996, p. 375). Tan (2004) proposes a three-factor model that examines how organizations acquire operations capability. Specifically, the study posits that the acquisition of operations capability is a function of an organization's commitment to the principles of quality management and to process improvement practices. Organizational knowledge enables an organization to use process knowledge to develop unique operational capabilities that create sustainable competitive advantage (Tan 2007). Operational capabilities that are developed by means of organizational knowledge in the form of worker competences lead to a sustainable competitive advantage to the firm (Tanriverdi, 2005).

On a more granular level, there is evidence suggesting a relationship between organizational knowledge creation and individual reflective indicators of operational capabilities as defined by Wu (2010). To acquire operational improvement capability workers must continually acquire and apply process knowledge to eliminate wasteful activities within a firm's processes (Swink & Hegarty 1998). Operational improvement consistently develops new methods of working for customers by applying the firm's technical knowledge to improve its processes (Benner & Tushman, 2003). Operational innovation involves the application of firm specific knowledge to promote experimentation with the intention of creating process variance as a means to drive organizational performance (Benner & Tushman, 2003). Operational innovation occurs via radical process change on a large scale that involves new knowledge or the significant departure from existing skills (Benner & Tushman, 2003).

Schroeder (2002) found that the operational capabilities that enable the customization of processes is the result of organizational knowledge creation that is firm-specific and path-dependent; therefore such organizational knowledge can lead to superior performance. Different operational practices are associated with underlying knowledge that enables a firm to customize its processes to meet the unique needs of customers (Schroeder, et al., 2002). The capabilities that result from situated knowledge creation can result in a firm developing customized and idiosyncratic manufacturing processes that yield performance advantages (St. John & Harrison, 1999). As Wu (2010) explains "operational customization is differentiated sets of skills, processes, and routines for the creation of knowledge through extending and customizing operations processes and systems" (p. 728). A firm's proficiency at introducing custom products or processes within existing operations requires specialized knowledge to meet market needs that are unique (Swink and Hegarty 1998).

Wu (2010) argues that operational flexibility is the same thing as operational responsiveness. Swink (2005) argues that cost efficiency and flexibility are two primary dimensions of manufacturing capability that are the result of specialized knowledge. They define flexibility as "the demonstrated ability to adapt or change plant-level operations with relatively little time or cost penalties" (p. 449). As well, Flynn (1999) found that knowledge-creating practices were positively associated with cost efficiency and flexibility. According to Swink (2005) workforce development practices are significantly associated with process flexibility. As an organizational capability, operational responsiveness is similar to technological and production knowledge within the operations system (Q. Zhang, et al., 2003). Operational reconfiguration involves unique organizational knowledge, skills, processes, and routines necessary to re-establish a fit between a firm's operations strategy, resources and the external market environment when a firm is faced with a rapidly changing situation in the market (Teece et al., 1997).

To summarize, there is broad support in the literature that supports our claim that organizational knowledge creation influences operational capabilities. Informed by the dynamic theory of organizational knowledge creation, RBT, and KBT, we argue that each of the four modes of knowledge creation will have an influence on operational capabilities as individual factors. According to Nonaka (1994) each of the knowledge modes is capable of creating organizational knowledge by itself. Therefore, it is reasonable to assume that the organizational knowledge generated by each knowledge mode will influence operational capabilities to some extent.

3.2.1.1 Socialization and Operational Capabilities

Socialization is the process of creating tacit knowledge through shared experience (Nonaka 1994). Linderman (2004) states that this mode of knowledge conversion requires that individuals interact with one another, and in doing so, to create tacit knowledge such as shared mental models and technical skills. Socialization practices combine the tacit knowledge of individuals to create a common understanding among team members about the process being improved (Fiol, 1994; Weick & Roberts, 1993). Process improvement practices can assist team members to socially engage with one another to develop a common understanding of problems and opportunities (Linderman 2010). It has been established in the literature that knowledge-creating practices can influence operational capabilities (Anand, et al., 2010; Peng, et al., 2008; Tan, et al., 2007; K. C. Tan, et al., 2004; Wu, et al., 2010). Further, that knowledge-creating practices engage the four modes of knowledge creation (Anand 2010), which includes socialization.

There is wide support in the literature that organizational knowledge creation as a second-order factor can influence operational capabilities (Grant, 1996; Peng, et al., 2008; S. Spear & Bowen, 1999; S. J. Spear, 2004; Tan, et al., 2007). We argue that if organizational knowledge creation can influence operational capabilities as a second-order construct, then it is reasonable to claim that socialization as a sub-factor of organizational knowledge creation will have some direct influence on operational capabilities as well. According to Nonaka (1994), socialization is capable of creating knowledge independently of the other three knowledge modes. However, Nonaka (1994) points out that “the ‘shareability’ of knowledge created by pure socialization may be limited and, as a result, difficult to apply in fields beyond specific context in which it was created" (Nonaka, 1994, p. 20). However, we argue that a certain amount of tacit knowledge, even if only localized, can still have some direct influence on operational capabilities.

- **H1: Socialization has a positive influence on operational capabilities.**

3.2.1.2 Combination and Operational Capabilities

Nonaka (1994) states that combination involves the use of social processes to combine different pieces of explicit knowledge held by individuals or information systems. Through exchange mechanisms such as meetings, telephone conversations and emails, individuals exchange and combine explicit knowledge. New knowledge can be created by repurposing and recombining existing information through the sorting, adding, re-categorizing, and re-contextualizing of explicit knowledge. It has been established in the literature that knowledge-creating practices can influence operational capabilities (Anand, et al., 2010; Peng, et al., 2008; Tan, et al., 2007; K. C. Tan, et al., 2004; Wu, et al., 2010). Further, that knowledge-creating practices engage the four modes of knowledge creation (Anand 2010), which includes combination.

There is wide support in the literature that organizational knowledge creation as a second-order factor can influence operational capabilities (Grant, 1996; Peng, et al., 2008; S. Spear & Bowen, 1999; S. J. Spear, 2004; Tan, et al., 2007). We argue that if organizational knowledge creation can influence operational capabilities as a second-order construct, then it is reasonable to claim that combination as a sub-factor of organizational knowledge creation can have some direct influence on operational capabilities. According to Nonaka (1994), combination is capable of creating knowledge independently of the other three knowledge modes.

Informed by Nonaka (1994), we reason that once explicit knowledge has been captured and documented, organizational knowledge creation can occur via the coordination of team members across boundaries of a firm and that such organization knowledge is actionable in ways that can influence operational capabilities. This might include, for example, “lessons learned” from previous process improvement efforts or insightful process data that enables other improvement teams to more effectively select and execute process improvement initiatives where the result of such initiatives enhances operational capabilities in some way.

- **H2: Combination has a positive influence on operational capabilities.**

3.2.1.3 Externalization and Operational Capabilities

Externalization is the conversion of tacit knowledge into explicit knowledge (Nonaka 1994). Externalization practices facilitate the explicit expression of tacit concepts and ideas in the form of language and visual schemata. These practices convert tacit knowledge held by individual members of a team into explicit forms that include numbers, written descriptions, diagrams, or pictures that facilitate group discussion and analysis (Anand, et al., 2010; Bohn, 1994; Hansen, et al., 1999). It has been established in the literature that knowledge-creating practices can influence operational capabilities (Anand, et al., 2010; Peng, et al., 2008; Tan, et al., 2007; K. C. Tan, et al., 2004; Wu, et al., 2010). Further, that knowledge-creating practices engage the four modes of knowledge creation (Anand 2010), which includes externalization.

There is wide support in the literature that organizational knowledge creation as a second-order factor can influence operational capabilities (Grant, 1996; Peng, et al., 2008; S. Spear & Bowen, 1999; S. J. Spear, 2004; Tan, et al., 2007). We argue that if organizational knowledge creation can influence operational capabilities as a second-order construct, then it is reasonable to claim that externalization as a sub-factor of organizational knowledge creation can have some direct influence on operational capabilities. According to Nonaka (1994), externalization is capable of creating knowledge independently of the other three knowledge modes. Informed by Nonaka (1994), we reason the process of converting tacit knowledge into codified explicit knowledge can occur in isolation to some extent as team members articulate their own perspectives via the use of tools such as metaphors, schemata, etc. We posit that the externalization process alone will result in the production of codified knowledge artifacts that can then be combined with existing data from other teams. In doing so, knowledge is disseminated across a firm promoting improvement activities that can ultimately influence positively operational capabilities.

- **H3: Externalization has a positive influence on operational capabilities.**

3.2.1.4 Internalization and Operational Capabilities

Internalization is the conversion of explicit knowledge into tacit knowledge; this knowledge mode has some similarity to the traditional concept of 'learning' is deeply related to "action" (Nonaka 1994, p. 17). In the context of process improvement, internalization practices facilitate the conversion of explicit knowledge into tacit knowledge, which can result in a common understanding among team members as to the best way to accomplish work (C. W. Choo, 1998; Grant, 1996). Internalization practices include efforts taken to understand and adopt best practices from other areas and projects within the firm (Tucker et al., 2007). Anand (2010) argues that such practices make it possible to capture explicit knowledge and then convert the knowledge into useful forms that can be comprehended and absorbed by others working in the processes. It has been established in the literature that knowledge-creating practices can influence operational capabilities (Anand, et al., 2010; Peng, et al., 2008; Tan, et al., 2007; K. C. Tan, et al., 2004; Wu, et al., 2010). Further, that knowledge-creating practices engage the four modes of knowledge creation (Anand 2010), which includes internalization.

There is wide support in the literature that organizational knowledge creation as a second-order factor can influence operational capabilities (Grant, 1996; Peng, et al., 2008; S. Spear & Bowen, 1999; S. J. Spear, 2004; Tan, et al., 2007). We argue that if organizational knowledge creation can influence operational capabilities as a second-order construct, then it is reasonable to claim that internalization as a sub-factor of organizational knowledge creation can have some direct influence on operational capabilities. Informed by Nonaka (1994) we argue that internalization by itself can result in operational experimentation where concepts are articulated in a trial and error way until they are refined enough to put to use. As this explicit knowledge is converted to tacit knowledge via the process of "learning by doing," teams are better able to identify and execute improvements to operations where such improvements can influence operational capabilities.

- **H4: Internalization has a positive influence on operational capabilities.**

3.2.2 Organizational Knowledge Creation and Firm Operational Performance

We argue that operational capabilities mediates the relationship between organizational knowledge creation and firm operational capabilities. This claim is informed by the dynamic theory of organizational knowledge creation (TKC), the Resource-based Theory of the firm (RBT), the Knowledge-based Theory of the firm (KBT), and diverse streams within the literature base. In this section we explore the literature from the theoretical perspectives of TKC, RBT, and

KBT relating to aspects of this mediated relationship. We then summarize the literature that supports this claim.

Scholars have investigated the influence of organizational knowledge creation on firm performance. Anand (2010) found that certain process improvement practices facilitate the creation of organizational knowledge, which can then influence performance outcomes. Similarly, Cua (2001) found that the use of knowledge-creating practices positively influences manufacturing performance outcomes. The study found that firms that engaged in these practices out performed companies that did not. Knowledge-creating practices contribute to the competitive performance of firms by creating new process knowledge (Anand, et al., 2010; Shah & Ward, 2003; Zu, et al., 2008). Thus, there is support in the literature that organizational knowledge creation can influence operational performance.

Other scholars have investigated the mediating role of operational capabilities between organizational knowledge and operational performance. Organizational knowledge enables a firm to use process knowledge to develop unique operational capabilities that create performance advantages (Tan 2007). Peng (2008) found that operational practices develop operational capabilities, which can then influence operational performance. Operational capabilities that are developed by means of organizational knowledge in the form of worker competences lead to superior firm performance (Tanriverdi, 2005). Thus, there is support in the literature that operational capabilities plays a mediating role between organizational knowledge creation and operational performance.

A large body of research within the operations management and strategy literature has been generated pertaining to the influence of operational capabilities on firm operational performance (Flynn & Flynn, 2004; K. C. Tan, et al., 2004). According to Wu (2010), “Operational capabilities are particularly desirable in generating positive intermediate outcomes, in terms of the way that a firm carries out an action or a series of actions” (Wu, et al., 2010, p. 741). Wu (2010) tested the six indicators of operational capabilities to determine how well they would predict the four operational performance dimensions of cost, quality, delivery, and flexibility. The study found that 22 out of the 24 tests had significant positive results, providing empirical evidence of the predictive validity of operational capabilities in influencing firm operational performance (Wu, et al., 2010, p. 741). Consistent with the findings of Wu (2010), other scholars have also empirically established that operational capabilities influences operational performance (Linderman, et al., 2004; Peng, et al., 2008; Tan, et al., 2007; K. C. Tan, et al., 2004; Wu, et al., 2010). Wheelwright & Hayes (1985) provide a theoretical linkage between the customization of operational processes (one of the indicators of operational capabilities) and operational performance. Similarly, Schroeder (2002) argues that greater customization of operational processes leads to higher operational performance in manufacturing. Thus, it has been established in the literature that operational capabilities can influence firm operational performance.

Much of the research pertaining to the influence of organizational knowledge creation on firm performance mediated by a firm’s capabilities has been motivated by RBT and KBT. From the RBT perspective, firms are successful because they are able to acquire and control resources in a productive way which gives the firm performance advantages that cannot easily be imitated by rivals; such inimitability is the result of a firm using proprietary process knowledge to convert resources into capabilities which is not transparent to other firms (J. Barney, 1991; Grant, 1991; Peteraf, 1993). From the KBT perspective, organizational capability is the outcome of knowledge integration; and the linkage between organizational capability and competitive advantage is mediated by this knowledge integration (Grant 1996). Further, “The extent to which a capability is 'distinctive' depends upon the firm accessing and integrating the specialized knowledge of its employees” (Grant 1996, p. 116). Similarly, knowledge can be a valuable resource that enables a firm to achieve performance advantages (Argote, et al., 2003; Kogut & Zander, 1992). The KBT suggests a positive link between knowledge and performance (Crossan 2003 in Easterby-Smith & Lyles, 2003, p. 133). Further, organizational knowledge is the critical resource that distinguishes a firm (Kogut and Zander, 1996; Spender, 1996). Thus, both RBT and KBT support the claim that the influence of organizational knowledge creation on operational performance is mediated by a firm’s capabilities.

These studies and theoretical perspectives are consistent with empirical observations in the business community. For example, Toyota introduced quality automobiles into the U.S. market in the 1980s that were both inexpensive and trendy. Toyota’s many competitors attempted to replicate the Toyota production system within their operations, but ultimately failed to do so (Tan 2007). Other companies such as Wal-Mart and Southwest Airlines have had similar success in their industries, and like with Toyota, competitors have not been able to replicate the success of these companies by merely imitating their operational practices. According to Tan (2007), there is nothing unique about the actual resources that these companies use. Instead, the superior performance enjoyed by these companies over their rivals is the result of how these resources are used which involves organizational knowledge and employee skills. This conclusion is supported by studies that have been conducted showing that firms in the same market sector with similar operational strategies can vary widely on performance levels (Cool & Schendel, 1988). One explanation of the performance differences is that the more successful firms achieved operational-level competences by using specialized knowledge with resources to produce efficient and effective outcomes resulting in better performance than competitors (Lawless, Bergh, & Wilsted, 1989). Thus, observations in the business community support the claim that the influence of organizational knowledge creation on firm operational performance is mediated by operational capabilities.

To summarize, it has been established that operational practices can facilitate the creation of organizational knowledge (Anand, et al., 2010; Mukherjee & Lapre, 1998; Nonaka, 1994). There is support in the literature that organizational knowledge creation can influence operational capabilities (Anand, et al., 2010; Peng, et al., 2008; Tan, et al., 2007; K. C. Tan, et al., 2004). There is a consensus that organizational knowledge creation can influence firm operational performance and that this influence is mediated by operational capabilities (Grant, 1996; Kogut & Zander, 1992; Nonaka, 1994; Spender & Grant, 1996; Wu, et al., 2010). Empirical observations in the business community also support these conclusions. It has been established that operational capabilities influence firm operational performance (Peng, et al., 2008; Tan, et al., 2007; Wu, et al., 2010). Therefore, informed by the dynamic theory of organizational knowledge creation, RBT, KBT, and previous studies, we argue that operational capabilities mediates the relationship between organizational knowledge creation and firm operational performance. We argue that the relationship is mediated because organizational knowledge is a resource for value creation rather than a business outcome (J. B. Barney, 1986; Grant, 1991; Spender, 1996). From the view of RBT and KBT, knowledge is a resource that enables a firm to convert other resources into value that can be sold to customers which means that organizational knowledge is an input into the value creation process (Grant, 1996; Schroeder, et al., 2002; Spender, 1996). Further, value creation is manifested through a firm's operational capabilities and it is these capabilities that ultimately create marketable value (Peng, et al., 2008; Wu, et al., 2010). Such capabilities need to be valuable, unique, and difficult for competitors to imitate if they are to influence firm performance in any significant way (Grant, 1996; Kogut & Zander, 1992; Spender, 1996; Spender & Grant, 1996), which further suggests that organizational knowledge is a key contributor to the development of these capabilities (Wu 2010).

Thus, we argue that for organizational knowledge to significantly influence firm operational performance, organizational knowledge must first be converted to operational capabilities (J. B. Barney, 1986; Grant, 1991; Ray, et al., 2004). An increase in operational capabilities can then directly influence firm operational performance. Based on this reasoning, we do not expect a direct effect of organizational knowledge creation on firm operational performance. Rather, we argue that this relationship is indirect. We investigate the influence of each mode of knowledge creation on operational capabilities and firm operational performance. We also investigate the influence of organizational knowledge creation as a second-order factor on operational capabilities and firm operational performance. We expect that both the first-order factors and the second-order factor will not have a significant direct influence on firm operational performance.

- **H5: Operational capabilities mediates a positive relationship between organizational knowledge creation and firm operational performance.**

3.3 Summary

This chapter has established the research context for the study with a discussion of the relationships between organizational knowledge creation, operational capabilities, and firm operational performance. A conceptual model was presented for the study and hypotheses for expected relationships between the constructs have been developed and are summarized in Table 3-1.

Table 3-2: Summary of Hypotheses

Hypothesis Number	Hypothesis
H1	Socialization has a positive influence on operational capabilities.
H2	Combination has a positive influence on operational capabilities.
H3	Externalization has a positive influence on operational capabilities.
H4	Internalization has a positive influence on operational capabilities.
H5	Operational capabilities mediates a positive relationship between organizational knowledge creation and firm operational performance.

CHAPTER 4

RESEARCH METHODOLGY AND DATA COLLECTION

This chapter describes the methods employed for data collection. The research design is discussed. The survey instrument development process is presented along with the details of conducting the survey and collecting the data.

4.1 Research Design

An online survey was conducted among manufacturing companies located in the United States to address these research questions. Manufacturing firms were selected based on their involvement in some form of process improvement, preferably Lean manufacturing. The target respondent within each firm was a manager involved in or familiar with the firm's process improvement initiatives and also familiar with the firm's operational capabilities and firm operational performance. A summary of the research design is provided in Table 4-1.

Table 4-1: Overview of Research Design

		Explanation
Research Method	Survey	This is an appropriate method to collect data at the organizational level.
Level of Analysis	Manufacturing Operation	Respondents asked to make subjective judgments about their manufacturing operation.
Unit of Analysis	The Firm	Respondents asked to make subjective judgments about the operational performance of their firm.
Data Source	Single key informant from target firms	Supports the research objective to achieve an acceptable response rate.
Target Respondent	A manager within each company familiar with company's process improvement initiatives, operational capabilities, and firm performance	The individuals within firms who are most Knowledgeable about the aspects of the research constructs. Process improvement and operational capability questions are presented in functional terms, so business professionals can answer them most effectively.
Target Firms	Manufacturing companies in the U.S.	This type of organization is often actively involved in process improvement.
Industries Included	Industrial machinery and equipment (3511-3599), chemical and allied products (2812-2899), automotive transportation and equipment (3711-3799), electronic and electric equipment (3624-3647), Food and beverage products (3845-4856)	These industries reflect a broad presence in the overall economy. The SIC codes are indicated in the parentheses.

4.2 Survey Instrument Development

The development of scales and measurement indicators is described in the following sections. For constructs in the conceptual model, survey questions are adapted from existing scales. According to Straub (1989), using established scales increases the reliability of the survey instrument and avoids the significant time and effort that would be invested in instrument development; and utilizing existing and validated scales enables future comparison with other research. Using a combination of multiple choice scales, five-point Likert scales, and seven-point semantic differential scales adapted from prior studies, the survey asked respondents to subjectively evaluate their company's knowledge-creating practices, operational performance, and firm operational performance. Ketokivi (2004) determined that the reliability and validity of perceptual operational measures are satisfactory and that the use of perceptual measures is warranted and were a viable alternative to actual performance data (Ketokivi & Schroeder, 2004)

4.2.1 Operationalizing the Construct of Organizational Knowledge Creation

For the purpose of operationalizing the four modes of knowledge creation (knowledge modes), this research builds on the work of Anand (2010) who investigated the effect of knowledge-creating practices on project performance in the context of process improvement. The study developed scales that related certain process improvement practices to specific modes of knowledge creation.

4.2.1.1 Socialization

Three items adapted from Anand (2010) were used to operationalize the construct of socialization (SOC). The items measured the extent to which there are discussions among process improvement team members, among team members and the customer(s) of the process being investigated or improved, and among team members and the supplier(s) of the process being investigated or improved. Each item was measured as a seven-point semantic differential scale ranging from one (not at all) through seven (to a great extent). Respondents could also answer “Don't’ Know” for any measurement item.

4.2.1.2 Combination

We adopt and modify the scale developed by Anand (2010) for operationalizing the construct of combination (COM). Three items operationalize this construct. One item measures the extent to which data analysis tools and methods are used for process improvement. One item measures the extent to which standardized procedures or standardized work are codified based on what is learned in process improvement events. One item measures the extent to which “lessons learned” form process improvement events are systematically recorded for future reference. Each item is measured as a seven-point semantic differential scale ranging from one (not at all) through seven (to a great extent). Respondents could also answer “Don't’ Know” for any measurement item.

4.2.1.3 Externalization

We adopt and modify the scale developed by Anand (2010) for operationalizing the construct of externalization (EXT). Three items operationalize this construct. One item measures the extent to which a firm formalizes the objectives of process improvements by preparing a business case document. One item measures the extent to which customer requirements (either internal or external) are formally and systematically captured. One item measures the extent to which subjective customer requirements are converted to objective requirements. Each item is measured as a seven-point semantic differential scale ranging from one (not at all) through seven (to a great extent). Respondents could also answer "Don't' Know" for any measurement item.

4.2.1.4 Internalization

We adopt and modify the scale developed by Anand (2010) for operationalizing the construct of internalization (INT). Three items operationalize this construct. One item measures the extent to which diagrams, charts, maps, or models are used during process improvement events. One item measures the extent to which codified reports are used to evaluate event performance during process improvement events. One item measures the extent to which codified reports are used to initiate discussions about the results of process improvement events. Each item is measured as a seven-point semantic differential scale ranging from one (not at all) through seven (to a great extent). Respondents could also answer "Don't' Know" for any measurement item.

4.2.1.5 Operationalization of Organizational Knowledge Creation Summary

All of the survey items that measure the four modes of knowledge creation are listed in Table 4-2.

Table 4-2: Operationalization of Knowledge Modes

Construct	Code	Survey Item
Socialization (SOC)	SOC1	There is discussion and/or collaboration among process improvement team members.
	SOC2	There is discussion between process improvement team members and the internal or external customers of a process being improved.
	SOC3	There is discussion between improvement team members and the internal or external suppliers of a process being improved.
Combination (COM)	COM1	Data analysis tools and statistical methods are used for process improvement.
	COM2	Standard work procedures are codified after the completion of process improvement events/activities.
	COM3	Knowledge (lessons learned) from process improvement activities is systematically recorded for future reference.
Externalization (EXT)	EXT1	We create business case documents that formalize the objectives of process improvement efforts.
	EXT2	We formally and systematically list implied customer requirements (internal and/or external customers).
	EXT3	Subjective customer requirements are converted into objective requirements.
Internalization (INT)	INT1	Diagrams, charts, forms, process/value stream maps and models are used to facilitate discussions during process improvement events/activities.
	INT2	Codified reports are used to initiate discussions during process improvement about the effectiveness of the process improvement event/activity.
	INT3	Codified reports are used to generate discussions about the results after the completion of process improvement events/activities.

4.2.2 Operationalizing the Construct of Operational Capabilities

To measure operational capabilities, this research builds on the work of Wu's (2010), theoretical framework for operational capabilities that consists of six dimensions which are reflective indicators: 1) operational improvement, 2) operational innovation, 3) operational customization, 4) operational cooperation, 5) operational responsiveness, and 6) operational reconfiguration. The following subsections describe the measurement items for each dimension on this construct.

4.2.2.1 Operational Improvement

We adopt and modify the scale developed by Wu (2010) for operationalizing the construct of operational improvement (IMP). Three items operationalize this construct. One item measures the extent that the firm continuously standardizes production processes. One item measures the extent to which a firm continuously reduces waste and/or variance. One item measures the extent to which the firm has learned from past successes and failures to improve processes continuously. Each item is measured as a seven-point semantic differential scale ranging from one (not at all) through seven (to a great extent). Respondents could also answer "Don't' Know" for any measurement item.

4.2.2.2 Operational Innovation

We adopt and modify the scale developed by Wu (2010) for operationalizing the construct of operational innovation (INN). Three items operationalize this construct. One item measures the extent to which a firm has created process innovations (radical improvement) that made current processes obsolete. One item measures the extent to which a firm has created process innovations that fundamentally changed a current process. One item measures the extent to which a firm created process innovations that made existing expertise in current processes obsolete. Each item is measured as a seven-point semantic differential scale ranging from one (not at all) through seven (to a great extent). Respondents could also answer “Don't’ Know” for any measurement item.

4.2.2.3 Operational Customization

We adopt and modify the scale developed by Wu (2010) for operationalizing the construct of operational customization (CUS). Four items operationalize this construct. One item measures the extent to which a firm has used its equipment in unique ways that differentiate the firm from their competitors. One item measures the extent to which a firm has modified and extended its product design process to better serve the needs of its customers. One item measures the extent to which a firm has modified and extended its planning systems to better serve the needs of its customers. One item measures the extent to which a firm has modified and extended its production processes to gain unique positions in the market. Each item is measured as a seven-point semantic differential scale ranging from one (not at all) through seven (to a great extent). Respondents could also answer “Don't’ Know” for any measurement item.

4.2.2.4 Operational Cooperation

We adopt and modify the scale developed by Wu (2010) for operationalizing the construct of operational cooperation (COO). Three items operationalize this construct. One item measures the extent to which a firm’s formal procedures facilitate teamwork across functions. One item measures the extent to which a firm’s employees are skilled at maintaining healthy relationships with each other to diagnose and solve problems. Each item is measured as a seven-point semantic differential scale ranging from one (not at all) through seven (to a great extent). Respondents could also answer “Don't’ Know” for any measurement item.

4.2.2.5 Operational Responsiveness

We adopt and modify the scale developed by Wu (2010) for operationalizing the construct of operational responsiveness (RES). Three items operationalize this construct. One item measures the extent to which a firm reduces uncertainty of equipment availability by quickly and easily changing the route of a job flow. One item measures the extent to which a firm adjusts for unexpected variations in components and material inputs quickly and easily. One item measures the extent to which a firm adjusts for variations in labor requirements easily and quickly. Each item is measured as a seven-point semantic differential scale ranging from one (not at all) through seven (to a great extent). Respondents could also answer “Don't’ Know” for any measurement item.

4.2.2.6 Operational Reconfiguration

We adopt and modify the scale developed by Wu (2010) for operationalizing the construct of operational reconfiguration (REC). Three items operationalize this construct. One item measures the extent to which a firm has adopted new and better practices to respond to market changes. One item measures the extent to which a firm can reconfigure (combine/release) resources to respond to market changes. One item measures the extent to which a firm develops competence and skills to respond to market changes. Each item is measured as a seven-point semantic differential scale ranging from one (not at all) through seven (to a great extent). Respondents could also answer “Don't’ Know” for any measurement item.

4.2.2.7 Operationalization of Operational Capabilities Summary

Measurement items for each of the six dimensions of operational capabilities were grouped in the same section of the online survey. The survey instructions for these items reads:

> *The next series of questions are about various aspects of your company's operational capabilities.*
>
> *The following three questions are about your company's capabilities in the area of operational IMPROVEMENT using tools like Lean and Six Sigma. Please rate the extent to which your company does the following on a scale from 1 (Not at all) to 7 (To a great extent). You can also answer, "Don't know".*

The survey items that measure the six dimensions of operational capabilities are summarized in Table 4-3.

Table 4-3: Operationalization of Mediator Variable

Construct	Code	Survey Item
Operational improvement (IMP)	IMP1	We continually standardize our production processes.
	IMP2	We continually eliminate waste and/or unwanted variance from our production processes.
	IMP3	Based on our experience, we improve our processes continually rather than on an ad hoc basis.
Operational innovation (INN)	INN1	We have created process innovations that made our prevailing processes obsolete.
	INN2	We have created process innovations that made existing expertise in the prevailing processes obsolete.
	INN3	We have created process innovations that fundamentally changed our prevailing processes.
Operational Customization (CUS)	CUS1	We use our production equipment in unique ways to differentiate us from our competitors.
	CUS2	Our production processes have been modified and/or extended to gain unique or superior positions in the market.
	CUS3	Our product design process has been modified and/or extended to better serve the needs of our customers.
	CUS4	Our planning systems have been modified and/or extended to better serve the needs of our customers.
Operational Cooperation (COO)	COO1	Our information system facilitates cooperation across company functions (i.e., production, purchasing, sales, etc.).
	COO2	Our standard operating procedures facilitate teamwork across company functions.
	COO3	Our employees collaborate with each other across company functions to diagnose and solve process problems.
Operational responsiveness (RES)	RES1	We can quickly change the route of a job flow when production equipment availability becomes a problem.
	RES2	We can easily accommodate unexpected variations in supply such as components and other material inputs.
	RES3	We can easily accommodate unexpected variations in production labor requirements.
Operational reconfiguration (REC)	REC1	We adopt better practices to respond to market changes.
	REC2	We reconfigure or combine resources in different ways to respond to market changes.
	REC3	We develop new competences and skills to respond to market changes.

4.2.3 Operationalizing the Construct of Firm Operational Performance

Firm operational performance is conceptualized as a construct consisting of four dimensions. We adopt the scale developed by Wu (2010) that investigated the effect of operational capabilities on operational performance along the dimensions of 1) cost performance, 2) product quality, 3) delivery performance, and 4) manufacturing flexibility. Each dimension of operational performance has multiple measurement items (see Table 4-4).

Respondents were asked to rate their company on each item relative to competitors. For example, "Please rate the cost performance of your company's manufacturing operation relative to competitors." Respondents could also answer "Don't' Know" for any measurement item. Each measurement item for product quality, delivery performance, and manufacturing flexibility is measured as a seven-point semantic differential scale ranging from -3 (Much Worse), -2, -1, 0 (About the Same), +1, +2, and +3 (Much Better). Thus, a response of -3 means that the respondent's company is much worse than competitors on that measurement item. Each cost performance measurement item is measured as a seven-point semantic differential scale ranging from -3 (Much Less), -2, -1, 0 (About the Same), +1, +2, and +3 (Much More). That is, the scale is reversed relative to the other three operational performance dimensions. Thus, a response of -3 means that the respondent's company has much less manufacturing costs than competitors, which makes the company better than competitors. All measurement items for each operational performance dimension were grouped on the same page of the online survey.

Table 4-4: Operationalization of Firm Operational Performance

Construct	Code	Survey Item
Cost Performance (COS)	COS1	Manufacturing unit cost
	COS2	Manufacturing overhead costs
	COS3	Total cost of operations (includes supply acquisition, setup, maintenance, service, etc.)
Quality Performance (QAL)	QPE1	Product conformance to established standards
	QPE2	Product durability
	QPE3	Product reliability
	QPE4	Product features.
	QPE5	Overall product quality
Delivery Performance (DEL)	DEL1	On time delivery
	DEL2	Delivery dependability (consistency)
	DEL3	Delivery quality (as ordered and completeness)
Flexibility Performance (FLE)	FLE1	Ability to adjust product volume in response to changes in market conditions
	FLE2	Ability to manufacture a range of products using the same equipment and/or production line

4.2.4 Control Variables

Eight control variables are used in this study and are summarized in Table 4-6. The purpose of the control variables is to explain any variance in the dependent variables with and without the influence of the independent variable(s) in order to determine whether some portion of the variance in the dependent variable is attributable to variables exogenous to constructs in the conceptual model. For example, we wanted to know if being unionized or non-unionized could explain any performance differences among firms in the sample. Similarly, we wanted to know if the number of employees in a firm could explain performance differences among the firms.

Table 4-6: Control Variables

Code	Survey Item	Possible Responses
QAL4	About how long has your company been implementing process improvement?	Not yet started; less than 1 year; between 1 and 3 years; between 3 and 5 years; more than 5 years; don't know
QAL5	In 2011, about how many process improvements did your company implement?	None; fewer than 10; between 10 and 50; between 50 and 100; more than 100; don't know or N/A
QAL6	How frequently does your company implement process improvements?	Weekly; monthly; quarterly; yearly; don't know or N/A
QAL10	Is your company privately held or a publicly-traded company?	Private; public
QAL11	Is your company unionized?	Yes; no
QAL12	How many employees does your company have?	Less than 100; less than 250; less than 500; more than 500
QAL13	What type of manufacturing does your company do?	(1) Discrete Manufacturing (i.e., cars, machines, electronics, etc.); (2) Process or Continuous Manufacturing (i.e., food, petroleum, chemicals, etc.)
QAL14	Do you have an employee(s) whose full-time job is to implement and/or direct process improvements within your company?	Yes; no

4.3 Data Collection

The online survey instrument was created using the Surveygizmo development tool. The survey instrument consists of 58 items – 12 items for organizational knowledge creation (see Table 4-2), 19 items for operational capabilities (see Table 4-3), 13 items for firm operational performance (see Table 4-4), 8 control variable items (see Table 4-6), 3 initial qualification questions (see Table 4-7), and 3 attention filter questions (see Table 4-9). Six items relating to firm financial performance (questions 54 through 59) and two items on the perceived effectiveness of process improvement (questions 65 and 66) are not part of this study. These items were added for future investigations.

Table 4-7: Survey Initial Qualification Questions

Question	Survey Item	Possible Responses
Q1	Which category best describes your organization? (In case more than one category applies, then select the broader category)	General services; healthcare, manufacturing; retail; transport & distribution; government; education
Q2	What is your primary job role with the company? (If more than one role applies, then select the broader role)	Purchasing; human resource management; executive management; manufacturing operations; sales & marketing; financial or accounting
Q3	Is the facility(s) that you work at or are responsible for located inside the United States?	Yes; no

A pilot test with a sample of five managers was conducted to assess the content validity of the survey instrument. Respondents for the pilot were selected based on their experience with process improvement in the manufacturing industry (see Table 4-8). Based on the feedback of the five pilot respondents, modifications were made to the survey instrument and the final survey was generated.

Table 4-8: Survey Pilot Test Respondent Qualifications

Respondent	Qualifications
1	Senior manager in a manufacturing firm
2	Senior manager in a manufacturing firm
3	Consultant that works extensively with manufacturing firms
4	Senior manager in a manufacturing firm
5	Consultant that works extensively with manufacturing firms

To qualify for the survey, respondents needed to be 1) involved with or familiar with their firm's process improvement activities, 2) familiar with their firm's operational capabilities across six different dimension, and 3) familiar with their firm's operational performance relative to competitors. To remove unqualified respondents before they completed the survey and to ensure the quality of the dataset, three types of filters were used: 1) three questions to assure the respondent met the above qualifications, 2) three attention filters to remove individuals who were not carefully reading survey items, and 3) additional filter logic (see Appendix A2 for a complete list of filter logic).

The first three questions on the survey are initial qualification questions that serve as the first filter for culling out unqualified respondents. If a respondent selected an answer other than what corresponds with the target respondent profile, the filter logic removed the respondent from the survey. Specifically, the respondent must answer "Manufacturing" for question 1. The respondent must answer either "executive management" or "manufacturing operations" for question 2. The respondent must answer, "yes" for question 3 meaning that they work in the

United States. Thus, if a respondent answered the first three questions in a way that identified them as non-qualified, the filter logic removed the respondent from the survey.

Three attention filter questions were included in the survey to ensure that respondents were not answering items randomly (see Table 4-9). Other survey filter logic was included to further ensure that respondents were both qualified and not answering items randomly by "looking for" a string of "don't know" responses on groups of survey items.

Table 4-9: Survey Attention Filter Questions

Code	Survey Item	Possible Responses
Q15	Please answer "Not at All" for this question (for survey calibration purposes).	1 (not at all) to 7 (to a great extent)
Q35	Please answer "To a Great Extent" for this question (for survey calibration purposes).	1 (not at all) to 7 (to a great extent)
Q52	Please answer "Much Better" for this question (for survey calibration purposes)	-3 (much worse) to +3 (much better)

Zoomerang online survey company was contracted to provide the survey panel. Zoomerang advertised the survey to their panel via their internal system. Respondents who desired to take the survey clicked the survey link provided and were then directed to the survey from the Zoomerang Website. The survey was open for nine days. A total of 3,404 respondents attempted the survey with 182 completing, 2,999 rejected by filter logic, and 223 abandoned (see Figure 4-1). It is not known what the "response rate" was on the survey since a third-party company controlled access to the survey panel. The overall survey completion rate was 5.3%.

This completion rate is low because of the stringent nature of the filter logic that was put in place to ensure the quality of the dataset.

Figure 4-1: Surveygizmo Control Panel

CHAPTER 5

QUANTITATIVE DATA ANALYSIS AND RESULTS

This chapter presents the analysis of the quantitative data obtained via the online survey. Section 5.1 presents the data analysis strategy followed by the sample size evaluation in section 5.2. Section 5.3 describes the normalization and outlier analysis methods. Next, validity and reliability of measurement items for all constructs is discussed in section 5.4. Section 5.5 discusses the process of creating the composite factors. Finally, section 5.6 describes the results of the data analyses.

5.1 Data Analysis Strategy

We follow the data analysis procedures suggested by Miles and Shevlin (2001) and Huck (1974) for a quantitative field study. The multiple regression method is selected to analyze the data because this is a variance study with multiple independent variables and one dependent variable with mediation involved. This study investigates the influence of the four independent variables (socialization, externalization, combination, and internalization) on a mediator variable (operational capabilities); the influence of organizational knowledge creation as a second-order factor (independent variable) on the mediator variable; and then the influence of the mediator variable on operational performance (the dependent variable). If a relationship exists between the modes of knowledge creation and operational capabilities, we want to know how much of the variance is explained by each of the independent variables — that is, how much each knowledge mode influences the dependent variable. We also want to know how much correlation exists between the independent variables. Multiple regression enables researchers to quantify the proportion of variance that each independent variable explains when the other independent variables are statistically controlled for. Multiple regression calculates these proportions by taking into account the correlations between independent variables, and assessing the effect of each independent variable when the influence of the other variables have been statistically removed (Huck, et al., 1974; Miles & Shevlin, 2001). We used the SPSS 20 statistical application package to perform all data analysis.

5.2 Sample Size Evaluation

At the end of the survey, 182 qualified completions were captured. After inspection, nine surveys were removed because they failed certain logics, leaving a final sample size of 173. This exceeded the minimum sample size of 108 based on our research design (Cohen (2003).

5.3 Normalization and Outlier Analysis

Scatterplots were generated for all measurement items to identify outliers in the dataset. One outlier survey was identified and removed. The sample size was reduced to 172.

Regression assumes normality of data (Huck, et al., 1974). All items were tested for normality (see Appendix B1for descriptive statistics) and were within the boundaries of normality. It is not surprising that most of the responses are skewed toward the higher number since all respondents completing the survey are involved in process improvement to some extent. Most measurement items have a skew of less than one. Twelve of the measurement items have skewness slightly over one. According to Miles (2001) skewness at or around a value of one will pose little problems with regression. REC2, however, has a skewness of 1.53, which we anticipate will be removed when the operational capabilities composite variable is formed.

Three measurement items have moderately high positive kurtosis. IMP3 is 1.21, CUS2 is 1.22 and REC2 is 1.54. However, according to Miles (2001), these values are still acceptable for regression. Further, this kurtosis is eliminated when the composite variables are formed. In addition to descriptive analysis, we also ran probability plots (P-P) for all measurement items which confirmed normality of the data.

5.4 Validity and Reliability

We tested reliability of sub-indicators in the CFA using Cronbach's coefficient alpha. Cronbach's alpha will generally increase as the inter correlations among measurement items increase, and is thus known as an internal consistency estimate of reliability for sub-indicators that load with the same factor (Cronbach, 1951).

We tested the measurement items for both discriminant and convergent validity using confirmatory factory analysis (CFA). CFA is a form of factor analysis that is used to test whether measures of a construct are consistent with a researcher's understanding of the nature of that construct (or factor) (Huck, et al., 1974; Nunnally & Bernstein, 2006). A factor analysis of all measurement items associated with a second-order construct was conducted to evaluate if the measurement items separate or load into the expected first-order sub constructs.

5.4.1 Modes of Knowledge Creation

A confirmatory factor analysis was performed using Principal Component Analysis (PCA) on the measurement items comprising the four dimensions of organizational knowledge creation or the modes of knowledge creation (knowledge modes) — Socialization (SOC), Combination (COM), Externalization (EXT), and Internalization (INT). Varimax rotation with Kaiser normalization was used for the analysis and SPSS was set to force four components in the factor analysis and to suppress small coefficients of .4 or less. Four measurement items associated with the knowledge modes failed to have a high loading on a factor and were removed from a second analysis – INT1, COM2, SOC1, and EXT2. A second factor analysis that excluded the four removed items confirms that the remaining sub-indicators load cleanly into four factors or components. Cumulative variance explained is 87.2%. Marginal cross loadings for EXT2 (.481) and COM3 (.505) are present but are ignored since there is a significant different between the cross loading and the corresponding factor loading. Further, additional component configurations do not yield better results. Based on the second CFA, INT1, COM2, SOC1, and EXT1 were removed from the dataset.

According to Nunnally (2006) a cross-loading should pose little problem if the cross loading differs by more than .2 from the corresponding factor loading. The EXT2 cross loading differs by .021 from the corresponding factor loading of .691. The COM3 cross loading differs by .18 from the corresponding factor loading of .680. We accept this difference as close enough for the purposes of this study. The final CFA indicates that the sub-indicators show discriminant and convergent validity.

Because only two sub-indicators remain for each mode of knowledge creation, we tested the reliability of these measurement items by calculating the Pearson correlation coefficient. For INT2 and INT3 r = .872. For SOC2 and SOC3 r = .746. For EXT2 and EXT3 r = .671 and for COM1 and COM2 r = .609. The Pearson coefficient correlations indicate that the sub-indicators are reliable. Table 5-3 shows the final CFA and reliability results. Matrix coefficients of .50 or less are suppressed for the aforementioned reason.

TABLE 5-3
CFA of the Modes of Knowledge Creation

Sub Indicators	*Name*	*Internalization* (INT)	*Socialization* (SOC)	*Externalization* (EXT)	*Combination* (COM)
Codified reports are used to initiate discussions during process improvement about the effectiveness of the process improvement event/activity.	*INT2*	.865			
Codified reports are used to generate discussions about the results after the completion of process improvement events/activities.	*INT3*	.826			
There is discussion between process improvement team members and the internal or external customers of a process being improved.	*SOC2*		.897		
There is discussion between improvement team members and the internal or external suppliers of a process being improved.	*SOC3*		.835		
Subjective customer requirements are converted into objective requirements.	*EXT3*			.856	
We formally and systematically list implied customer requirements (internal and/or external customers).	*EXT2*			.691	
Data analysis tools and statistical methods are used for process improvement.	*COM1*				.772
Knowledge (lessons learned) from process improvement activities is systematically recorded for future reference.	*COM3*	.505			.680
Eigenvalue		1.99	1.81	1.61	1.56
Percentage of variance extracted		24.9	22.6	20.1	19.5
Cumulative percentage of variance extracted		24.9	47.6	67.7	87.2
Two-tailed Pearson correlation ($p < .01$)		.872	.746	.671	.609

NOTE: Factor analysis used was PCA with varimax rotation and Kaiser normalization; Loadings < .50 suppressed.

5.4.2 Operational Capabilities

A confirmatory factor analysis was performed using Principal Component Analysis (PCA) on the measurement items comprising the six dimensions of operational performance — operational cooperation (COO), operational reconfiguration (REC), operational responsiveness (RES), operational customization (CUS), operational improvement (IMP), and operational innovation (INN). Varimax rotation with Kaiser normalization was used for the analysis and SPSS was set to force six components in the factor analysis and to suppress small coefficients of .4 or less. The result indicated cross loadings on some sub-indicators across multiple components. Specifically, CUS3 cross loads with REC, CUS4 cross loads with COO, and INN3 cross loads with IMP. Another factor analysis was performed that excluded the sub-indicators CUS3, CUS4, and INN3. Again, varimax rotation with Kaiser normalization was used for the analysis and SPSS was set to force six components in the factor analysis and to suppress small coefficients of .4 or less.

The second factor analysis shows clean loadings on all six indicators of operational capabilities (see Table 5-4). All RES indicators load on the factor operational responsiveness, all COO indicators load on the factor operational cooperation, all REC indictors load on the factor operational reconfiguration, all IMP indicators load on the factor operational improvement, all CUS indicators load on the factor operational customization, and all INN indicators load on the factor operational innovation. Cumulative variance explained is 81.2%. The final CFA indicates that the sub-indicators for the six dimensions of operational capabilities show discriminant and convergent validity. As a result of the second CFA, the sub-indicators CUS3, CUS4, and INN3 were removed from the dataset.

A Cronbach's coefficient alpha was calculated on four sub-indicators loading on the same factor to determine the reliability of the items. The alpha for RES items is .852, the alpha for COO items is .874, the alpha for REC items is .913, and the alpha for IMP items is .859. The Pearson correlation coefficient was calculated for CUS and INN because there are only two items for each of these. For the CUS items, $r = .678$ and for the two INN items, $r = .644$. These analyses indicate that the sub-indicators loading on their respective factors are reliable. The Cronbach's alphas and the Pearson coefficients indicate that the sub-indicators associated with the six dimensions of operational capabilities are reliable. Table 5-4 shows the final CFA and reliability results.

TABLE 5-4
CFA of Operational Capabilities

Sub Indicators — *RES (Responsiveness); COO (Cooperation); REC (Reconfiguration) IMP (Improvement); CUS (Customization); INN (Innovation)*	*Name*	(RES)	(COO)	(REC)	(IMP)	(CUS)	(INN)
We can easily accommodate unexpected variations in supply such as components and other material inputs.	*RES2*	.832					
We can quickly change the route of a job flow when production equipment availability becomes a problem.	*RES1*	.808					
We can easily accommodate unexpected variations in production labor requirements.	*RES3*	.758					
Our information system facilitates cooperation across company functions.	*COO1*		.781				
Our employees collaborate with each other across company functions to diagnose and solve process problems.	*COO3*		.767				
Our standard operating procedures facilitate teamwork across company functions.	*COO2*		.761				
We develop new competences and skills to respond to market changes.	*REC3*			.780			
We adopt better practices to respond to market changes.	*REC1*			.777			
We reconfigure or combine resources in different ways to respond to market changes.	*REC2*			.739			
We continually standardize our production processes.	*IMP1*				.816		
Based on our experience, we improve our processes continually rather than on an ad hoc basis.	*IMP3*				.738		
We continually eliminate waste and/or unwanted variance from our production processes.	*IMP2*				.631		
We use our production equipment in unique ways to differentiate us from our competitors.	*CUS1*					.860	
Our production processes have been modified and/or extended to gain unique or superior positions in the market.	*CUS2*					.825	
We have created process innovations that made existing expertise in the prevailing processes obsolete.	*INN2*						.891
We have created process innovations that made our prevailing processes obsolete.	*INN1*						.729
Eigenvalue		2.49	2.43	2.40	2.27	1.83	1.67
Percentage of variance extracted		15.6	15.2	14.9	14.2	11.4	10.6
Cumulative percentage of variance extracted		15.6	30.8	45.8	59.9	71.4	81.9
Cronbach's Alpha (*two-tailed Pearson correlation $p < .01$)		.852	.874	.913	.859	*.678	*.644

NOTE: Factor analysis used was PCA with varimax rotation and Kaiser normalization; Loadings < .40 suppressed.

5.4.3 Firm Operational Performance

A confirmatory factor analysis was performed using Principal Component Analysis (PCA) on the measurement items comprising the four dimensions of operational performance — product quality performance (QPE), delivery performance (DEL), manufacturing cost performance (COS), and manufacturing flexibility performance (FLE). Varimax rotation with Kaiser normalization was used for the analysis and SPSS was set to force four factors. The DEL3 measurement indicator cross-loads with product quality performance. A second CFA omitting DEL3 is conducted and shows clean factor loadings on all four factors or components. All QPE indicators load on product quality performance, all COS indicators load on manufacturing cost performance, all DEL indicators load on delivery performance, and all FLE indicators load on manufacturing flexibility performance. The cumulative variance explained is 80.9%. The final CFA indicates that the sub-indicators for the four dimensions of firm operational performance show discriminant and convergent validity (see Table 5-5). Based on the second CFA, DEL3 was removed from the dataset.

A Cronbach's coefficient alpha was calculated on two sub-indicators loading on the same factor to determine the reliability of the items. The alpha for QPE items is .922 and the alpha for COS items is .885. The Pearson correlation coefficient was calculated for DEL and FLE because there are only two items associated with each. For the DEL items, r =.824 and for the two FLE items, r = .492. Although low, the Pearson correlation coefficient for FLE indicates that a sufficient relationship exists between the two items to keep them in the survey instrument. The Cronbach's alphas and the Pearson coefficients indicate that the sub-indicators associated with the four dimensions of firm operational performance are reliable. Table 5-5 shows the final CFA and reliability results.

TABLE 5-5
CFA of Firm Operational Performance

Sub Indicators	*Name*	Quality (QPE)	Cost (COS)	Delivery (DEL)	Flexibility (FLE)
Product reliability	*QPE3*	.911			
Product durability	*QPE2*	.904			
Overall product quality	*QPE5*	.878			
Product conformance to established standards	*QPE1*	.801			
Product features	*QPE4*	.735			
Manufacturing overhead costs	*COS2*		.920		
Total cost of operations (includes supply acquisition, setup, maintenance, service, etc.)	*COS3*		.908		
Manufacturing unit cost	*COS1*		.876		
On time delivery	*DEL1*			.917	
Delivery dependability (consistency)	*DEL2*			.882	
Ability to manufacture a range of products using the same equipment and/or production line	*FLE2*				.893
Ability to adjust product volume in response to changes in market conditions	*FLE1*				.700
Eigenvalue		3.83	2.45	1.92	1.50
Percentage of variance extracted		31.9	20.4	16.0	12.5
Cumulative percentage of variance extracted		31.9	52.4	68.4	80.9
Cronbach's Alpha (*two-tailed Pearson correlation $p < .01$)		.922	.885	*.824	*.492

NOTE: Factor analysis used was PCA with varimax rotation and Kaiser normalization; Loadings < .40 suppressed.

5.5 Composite Factor Development

A composite factor is a manipulation of sub-factors to produce an aggregate measure of a variable. A composite factor is formed when individual factors are compiled into a single number on the basis of an underlying model and measures multi-dimensional factors that cannot be captured by a single factor (Organisation for Economic, Development, European, & European Commission. Joint Research, 2008; Saltelli, 2007). A composite factor should be based on a theoretical framework that guides in the selection and combining of factors in a manner that reflects the dimensions or structure of the phenomena being measured (Cherchyel et al., 2008). Composite factors often rely on equal weighting where all measurement factors are given the same weight (Saltelli, 2007).

The strengths and weaknesses of composite factors largely derive from the quality of the underlying factors. To ensure that the structure of the composite factor is well defined, it is necessary to determine whether the set of available first-level factors is sufficient or appropriate to describe the phenomenon. Factor analysis along with Cronbach coefficient alpha is a good way to explore whether the dimensions of the phenomenon are statistically well balanced in the composite factor (Cherchyel, et al., 2008; Saltelli, 2007). We have utilized both factor analysis and Cronbach's alpha in the process of developing the composite factors for this study.

We developed the composite factors using a two-stage process. First we developed second-level factors by combining multiple first-level factors for identified factor groupings into a single second-level factor. The result is multiple second-level factors that capture the theoretical dimensions of the constructs under study. Second, we combined the second-level factors into a third-level composite factor for each construct in the conceptual model — organizational knowledge creation (KNOW), operational capabilities (OPCAP), and firm operational performance (OPPER). The third-level factors are then used in multiple regression and mediation analysis to test the hypotheses associated with the conceptual model proposed in this study. We used the averaging method to form composite factors where the first-level factors are equally weighted in the composite factor. We used an equal weighting averaging method to develop the composite factors using the following formula:

$\frac{\sum_{i=1}^{n} X_i}{n}$, where X is the reported value of a first-level factor on a survey. First-level factor values or second-level factor values for a selected factor grouping are added together and then divided by the number of first-level factors or second-level factors. Missing values in the dataset were not imputed, but rather left missing.

5.5.1 Organizational Knowledge Creation

We developed second-level factors for the four modes of knowledge creation. SOC2 and SOC3 were combined to form second-level factor SOC_X; COM1 and COM2 were combined to form second-level factor COM_X; EXT2 and EXT3 were combined to form second-level factor EXT_X; and INT2 and INT3 were combined to form second-level factor INT_X. The result is four second-level factors — SOC_X, COM_X, EXT_X, INT_X — that define the dimensions of the construct organizational knowledge creation via the modes of knowledge creation. We then combined the second-level factors to form a singe third-level factor for organizational knowledge creation (KNOW) (see Table 5-7).

Table 5-7: Composite Factor Development - Organizational Knowledge Creation

First Level Factors	Second Level Factors	Third Level Factors
SOC2 →	SOC_X →	KNOW
SOC3 →		
COM1 →	COM_X →	
COM2 →		
EXT2 →	EXT_X →	
EXT3 →		
INT2 →	INT_X →	
INT3 →		

For example, the SOC_X second-level factor is formed by the following arithmetic operations:

(SOC2 + SOC3) / 2 = SOC_X

And, the third-level factor KNOW is formed by:

(SOC_X + COM_X + EXT_X + INT_X) / 4 = KNOW

5.5.2 Operational Capabilities

We developed second-level composite factors for the six dimensions of operational capabilities. IMP1, IMP2, and IMP3 were combined to form IMP_X; INN1 and INN2 were combined to form INN_X; CUS1 and CUS2 were combined to form CUS_X; COO1, COO2, and COO3 were combined to form COO_X; RES1, RES2, and RES3 were combined to form RES_X; and REC1, REC2, and REC3 were combined to form REC_X. The result is six second-level factors — IMP_X, INN_X, CUS_X, COO_X, RES_X, REC_X — that define the dimensions of the construct operational capabilities. We then combined the resulting second-level factors to form a single third-level factor for operational capabilities (OPCAP) (see Table 5-8).

Table 5-8: Composite Development – Operational Capabilities

First Level Factors	Second-level Factors	Third-level Factors
IMP1 →	IMP_X →	OPCAP
IMP2 →		
IMP3 →		
INN1 →	INN_X →	
INN2 →		
CUS1 →	CUS_X →	
CUS2 →		
COO1 →	COO_X →	
COO2 →		
COO3 →		
RES1 →	RES_X →	
RES2 →		
RES3 →		
REC1 →	REC_X →	
REC2 →		
REC3 →		

5.5.3 Firm Operational Performance

We developed second-level factors for the four dimensions of firm operational performance. COS1, COS2, and COS3 were combined to form the second-level factor COS_X; QPE1, QPE2, QPE3, QPE4, and QPE5 were combined to form the second-level factor QPE_X; DEL1 and DEL2 were combined to form the second-level factor DEL_X; and FLE1 and FLE2 were combined to form the second-level factor FLE_X. The result is four second-level factors — COS_X, QPE_X, DEL_X, FLE_X — that define the dimensions of the construct firm operational performance. We then combined the resulting intermediate factors to form a single third-level factor for firm operational performance (OPPER) (see Table 5-9).

Table 5-9: Composite Development – Firm Operational Performance

First Level Factors	Second-level Factors	Third-level Factors
COS1 →	COS_X →	OPPER
COS2 →		
COS3 →		
QPE1 →	QPE_X →	
QPE2 →		
QPE3 →		
QPE4 →		
QPE5 →		
DEL1 →	DEL_X →	
DEL2 →		
FLE1 →	FLE_X →	
FLE2 →		

5.6 Results

In this section we test each of the hypotheses associated with conceptual model (see Figure 3-1). Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, and multicollinearity.

5.6.1 Hypotheses 1 – 4

We argue that there is a positive relationship between organizational knowledge creation via each of the four modes of knowledge creation (knowledge modes) and operational capabilities. Hypotheses 1-4 are stated below.

H1: *Socialization has a positive influence on operational capabilities.*
H2: *Combination has a positive influence on operational capabilities.*
H3: *Externalization has a positive influence on operational capabilities.*
H4: *Internalization has a positive influence on operational capabilities.*

The four knowledge modes are the independent variables of interest and are represented by the second-level factors SOC_X, COM_X, EXT_X, and INT_X. The dependent variable is the third-level factor for operational capabilities (OPCAP). To control for possible causes of variance in operational capabilities other than from the knowledge modes, we also investigate the influence of the control variables QAL5, QAL10, QAL11, QAL12, QAL13, and QAL14 on operational capabilities (see Table 4-6 for the list of control variables).

Hierarchical multiple regression was performed to assess the ability of the knowledge modes (SOC_X, COM_X, EXT_X, INT_X) to predict levels of operational capabilities (OPCAP) after controlling for the influence of the six control variables. The results of this analysis are summarized in Table 5-11. The six control variables were entered at step 1, explaining 7.6% of the variance in operational capabilities. After entry of the four knowledge modes at step 2, the total variance explained by the model as a whole is 51.2%, $F(10, 143) = 17.07$, $p < .001$. The four knowledge modes explain an additional 43% of the variance in operational capabilities after controlling for QAL5, QAL10, QAL11, QAL12, QAL13, and QAL14, R squared change = .43, F change $(4, 143) = 33.90$, $p < .001$. In model 2, none of the control variables make a statistically significant contribution to the equation. The beta value for SOC_X is .28, $p < .001$; the beta value for COM_X is .20, $p < .05$; the beta value for EXT_X is .12, n.s. and the beta value for INT_X is .28, $p < .01$. This analysis reveals that socialization and internalization make the most unique contributions with a moderate contribution from combination. Surprisingly, externalization as a first-order factor does not make a significant contribution to the equation. Thus, we reject the null hypothesis for H1, H2, and H4 and accept the null hypothesis for H3

Table 5-11: Hierarchical Regression Results for H1, H2, H3, H4

Dependent: OPCAP			*Beta*	R^2	adj. R^2	SE est.	df	F	ΔR^2	ΔF
Step 1: Controls										
X1:	QAL5		.27**							
X2:	QAL10		.01^{ns}							
X3:	QAL11		.04^{ns}							
X4:	QAL12	Model 1	-.15^{ns}	0.112	0.076	0.943	6 (147)	3.09**	.112	3.09**
X5:	QAL13		.03^{ns}							
X6:	QAL14		.19*							
Step 2: With Knowledge Modes										
X1:	QAL5		.08^{ns}							
X2:	QAL10		-.03^{ns}							
X3:	QAL11		.05^{ns}							
X4:	QAL12		-.09^{ns}							
X5:	QAL13		-.01^{ns}							
X6:	QAL14	Model 2	-.04^{ns}	0.544	0.512	0.685	10 (143)	17.07***	0.432	33.89***
X7:	SOC_X		.28***							
X8:	EXT_X		12^{ns}							
X9:	COM_X		.20*							
X10:	INT_X		.28**							

$^{ns}p > .05$ $\quad$ * $p < .05$ $\quad$ ** $p < .01$ $\quad$ *** $p < .001$

5.6.2 Hypotheses 5

We argue that organizational knowledge creation has an indirect relationship with firm operational performance via operational capabilities. Specifically, we posit that organizational knowledge creation predicts firm operational performance through operational capabilities. A variable can be called a mediator "to the extent that it accounts for the relation between the predictor and the criterion" (Baron & Kenny, 1986, p. 1176). We tested the mediated relationship between organizational knowledge creation and firm operational performance using

Baron & Kenny's four-step process for testing a mediated relationship. The results of this analysis are summarized in Table 5-12.

H5: *Operational capabilities mediates a positive relationship between organizational knowledge creation and firm operational performance.*

The third-level factor for organizational knowledge creation (KNOW) is the independent variable of interest (a second-order construct). The third-level factor for operational capabilities (OPCAP) is the mediator variable, and the third-level factor for firm operational performance (OPPER) is the dependent variable. We use regression to test the model X → M → Y. Baron and Kenny's four-step process for testing for the existence of a mediated relationship is summarized below (Baron & Kenny, 1986; Miles & Shevlin, 2001; Preacher & Hayes, 2004):

- Step 1: Test that X is a significant predictor of Y
- Step 2: Test that X is a significant predictor of M
- Step 3: Test that M is a significant predictor of Y when controlling for X
- Step 4: If M completely mediates for the relationship between X and Y, the effect of X, when controlling for M, should be zero (or at least not significant).

In step 1 of the Baron and Kenny test for mediation, we conducted a simultaneous regression analysis to determine if KNOW is a significant predictor of OPPER (X → Y). Results indicate that the total variance explained by the model as a whole is 14.3%, R square = .143, $F(1, 155) = 25.88$, $p < .001$. Thus, KNOW is a significant predictor of OPPER, satisfying Baron and Kenny's first condition for mediation.

In step 2, we conducted a simultaneous regression analysis to determine if KNOW is a significant predictor of OPCAP (X → M). Results indicate that the total variance explained by the model as a whole is 55.1%, R square = .551, F(1, 156) = 191.23, p < .001. Thus, KNOW is a significant predictor of OPPER, satisfying Baron and Kenny's second condition for mediation.

In step 3, we assess the ability of OPCAP (M) to predict levels of OPPER (Y) after statistically controlling for the influence of KNOW (X). Hierarchical multiple regression was conducted using KNOW and OPCAP as predictors and OPPER as the outcome. KNOW was entered into the regression first, explaining 14.3% of the variance in OPPER (already established in step one). After entry of OPCAP into the regression, the total variance explained by the model as a whole was 27.5%, F(2, 154) = 29.16, p < .001. OPCAP explained an additional 13.2% of the variance in OPPER after controlling for KNOW, R squared change =.132, F change (1, 154) = 27.94, p < .001. Thus, OPCAP is a significant predictor of OPPER when controlling for KNOW, satisfying Baron and Kenny's third condition for mediation.

Table 5-12: Hierarchical Regression Mediation Test Results for H5

Dependent: OPPER		*Beta*	R^2	adj. R^2	SE est.	df	F	ΔR^2	ΔF
Step 1: X --> Y									
X: KNOW	Model 1	$.38^{***}$	0.143	0.138	0.679	1 (155)	25.88^{***}	0.143	25.88^{***}
Step 2: X --> M									
X: KNOW	Model 1	$.74^{***}$	0.551	0.548	0.659	1 (156)	191.23^{***}	0.551	191.23^{***}
Dependent: OPCAP									
Steps 3 & 4: X + M --> Y									
X1: KNOW X2: OPCAP	Model 2	$-.02^{ns}$ $.54^{***}$	0.275	0.265	0.627	2 (154)	29.16^{***}	0.132	27.94^{***}

^{ns} p > .05 * p < .05 ** p < .01 *** p < .001

In step 4, we evaluate the unique contributions of KNOW and OPCAP to the equation. In the model 2, the effect of KNOW is zero (beta = -.02, n.s.). However, OPCAP makes a statistically significant contribution to the equation, beta = .54, $p < .001$. Thus, the effect of KNOW when controlling for OPCAP is zero indicating that OPCAP is a complete mediator of the relationship between KNOW and OPPER, satisfying Baron and Kenny's fourth condition for mediation.

We argue that if operational capabilities mediates the relationship between organizational knowledge creation as a second-order factor and firm operational performance, then operational capabilities will also mediate the relationship between each of the four knowledge modes and operational performance. We test these four mediated relationships using Baron & Kenny's four-step process for confirming mediation as described in this section. The results of this analysis are summarized in Table 5-13.

Simultaneous regressions were performed to assess the ability of each of the four knowledge modes (SOC_X, COM_X, EXT_X, and INT_X) to predict OPPER (X →Y). In step 1, each knowledge mode individually was regressed onto OPPER. Results indicate that each knowledge mode is a significant predictor of OPPER, satisfying Baron and Kenny's first condition for mediation. In step 2, each knowledge mode was regressed onto the mediator variable OPCAP (X → M). Results confirm that each knowledge mode is a significant predictor of the mediator OPCAP, satisfying Baron and Kenny's second condition for mediation.

In steps 3 and 4, we assess the ability of OPCAP (M) to predict levels of OPPER (Y) after statistically controlling for the influence of each of the knowledge modes (X_n). Hierarchical multiple regression was performed using each of the knowledge modes (individually) and OPCAP as predictors and OPPER as the outcome. After entry of OPCAP into the regression for each knowledge mode, the total variance explained by the model as a whole was between .50 and .55, where OPCAP explained an additional 16% to 19% of the variance in OPPER after controlling for the influence of each knowledge mode. In model 2, the unique contribution of each knowledge mode to the equation is zero, indicating that OPCAP is a complete mediator. Thus, OPCAP is a significant predictor of OPPER when controlling for each of the four knowledge modes, satisfying Baron and Kenny's third and fourth conditions for mediation.

Table 5-13: Regression Analysis Results Testing Mediation of Knowledge Modes

Dependent: OPPER		*Beta*	R^2	adj. R^2	SE est.	df	F	ΔR^2	ΔF
Step 1: X --> Y									
X: EXT_X	Model 1	$.34^{***}$	0.112	0.107	0.692	1 (160)	20.23^{***}	0.112	20.23^{***}
X: SOC_X	Model 1	$.29^{***}$	0.084	0.078	0.703	1 (162)	14.79^{***}	0.084	14.79^{***}
X: COM_X	Model 1	$.31^{***}$	0.095	0.089	0.699	1 (162)	16.94^{***}	0.095	16.94^{***}
X: INT_X	Model 1	$.31^{***}$	0.094	0.088	0.699	1 (162)	16.77^{***}	0.094	16.77^{***}
Step 2: X --> M									
X: EXT_X	Model 1	$.59^{***}$	0.348	0.344	0.794	1 (161)	85.82^{***}	0.348	85.82^{***}
X: SOC_X	Model 1	$.60^{***}$	0.362	0.358	0.786	1 (163)	92.31^{***}	0.362	92.31^{***}
X: COM_X	Model 1	$.61^{***}$	0.372	0.368	0.779	1 (163)	96.44^{***}	0.372	96.44^{***}
X: INT_X	Model 1	$.63^{***}$	0.397	0.393	0.764	1 (163)	107.22^{***}	0.397	107.22^{***}
Dependent: OPCAP									
Steps 3 & 4: X + M --> Y									
X1: EXT_X X2: OPCAP	Model 2	$.04^{ns}$ $.50^{***}$	0.275	0.266	0.627	2 (159)	30.22^{***}	0.163	35.82^{***}
X1: SOC_X X2: OPCAP	Model 2	$-.04^{ns}$ $.55^{***}$	0.275	0.266	0.627	2 (161)	30.41^{***}	0.192	42.34^{***}
X1: COM_X X2: OPCAP	Model 2	$-.02^{ns}$ $.54^{***}$	0.275	0.266	0.627	2 (160)	30.29^{***}	0.18	39.69^{***}
X1: INT_X X2: OPCAP	Model 2	$-.04^{ns}$ $.55^{***}$	0.275	0.266	0.627	2 (160)	30.39^{***}	0.182	40.08^{***}

$^{ns}p > .05$ $^{*}\ p < .05$ $^{**}\ p < .01$ $^{***}\ p < .001$

In step 4, we evaluate the unique contributions of each of the four knowledge modes and OPCAP to the equation. In model 2, the effect of each of the four knowledge modes is zero. That is, the knowledge modes individually make no significant contribution to the equation. However, OPCAP makes statistically significant contribution to the equation, beta = .55, $p < .001$. Thus, the effect the four knowledge modes individually when controlling for OPCAP is zero indicating that OPCAP is a complete mediator of the relationship between the four knowledge modes individually and OPPER, satisfying Baron and Kenny's fourth condition for complete mediation.

To confirm these findings, we also performed a path analysis-based mediation test using the "Process" SPSS macro developed by Andrew Hayes (Preacher & Hayes, 2004) where Y = OPPER, X = KNOW, and M = OPCAP. The number of bootstrap samples was 10,000. The confidence level for all confidence intervals was 95.0. The total variance explained by the model as a whole was 29.4%, R square = .294, $F(2, 151) = 31.5$, $p < .001$. The coefficient for OPCAP was .446, $p < .001$, while the coefficient for KNOW was -.042, n.s., indicating that the effect of KNOW when controlling for OPCAP is zero or non significant. These results are similar to the aforementioned regression outputs. Based on the results of these analyses, we reject the null hypothesis for H5.

CHAPTER 6

DISCUSSION AND IMPLICATIONS

In this section, we discuss the findings of this study and their implications. We also discuss the contribution to theory and practice. We conclude our discussion with study limitations and possible future research directions.

6.1 Summary of Results and Discussion

In this study, we investigated the effect of organizational knowledge creation on firm operational performance and the role of operational capabilities as a mediating factor in this relationship. To test this, we investigated the direct influence that each mode of knowledge creation (as first-order factors) has on operational capabilities and firm operational performance. We also investigated the influence of organizational knowledge creation as a second-order factor on operational capabilities and firm operational performance. We argue that the influence of organizational knowledge creation on firm operational performance is mediated by operational capabilities. We further argue that this mediated relationship applies to each of the knowledge modes individually and organizational knowledge creation as a second-order factor (via a third-level composite factor). We used Baron and Kenny's (1986) method for testing the existence of mediated relationships.

The most common method for testing mediation in social science research was proposed by Baron & Kenny in 1986 (Frazier, Tix, & Barron, 2004). According to Baron & Kenny (1986), a mediator is a variable that explains the relationship between a predictor variable and an outcome variable. That is, a mediator is the mechanism or path through which a predictor variable influences an outcome variable. In this study, we argue that the influence of organizational knowledge creation on firm operational performance is mediated by operational capabilities. According to Baron (2004), the Baron and Kenny test for mediation involves four steps that are performed with three regression equations to establish that a variable (e.g., operational capabilities) mediates the relationship between a predictor variable (e.g., organizational knowledge creation) and an outcome variable (e.g., firm operational performance). In step one, it is required that there is a significant relationship between the predictor variable and the outcome variable. This was established for each of the knowledge modes individually and organizational knowledge creation as a second-order factor. In the second step it is required to show that the predictor variable has a relationship to the mediator variable. This was also established for each of the knowledge modes individually and organizational knowledge creation as a second-order factor. In the third step it is required to show that the mediator variable (e.g., operational capabilities) has a relationship to the outcome variable (e.g., firm operational performance). This was established for each of the knowledge modes individually and organizational knowledge creation as a second-order factor. In the final step it is required to show that the strength of the relationship between the predictor variable and the outcome variable is either significantly reduced (partial mediation) or is zero (complete mediation) when the mediator is added to the model (Frazier, et al., 2004). Our findings indicate that operational capabilities is a complete mediator of the relationship between organizational knowledge creation as a second-order factor and firm operational performance (see Table 5-12). Our findings also indicate that operational capabilities is a complete mediator of the relationship between each knowledge mode individually and firm operational performance (see Table 5-13).

We also tested the influence that each of the knowledge modes has on operational capabilities while statistically controlling for the influence of the other knowledge modes. We performed a hierarchical regression where the four knowledge modes as a group were entered in step two of the regression after the control variables (see Table 5-11). We found that socialization and internalization have the strongest influence on operational capabilities with a relatively moderate influence from combination. Surprisingly, externalization as a first-order factor does not have a significant influence on operational capabilities when controlling for the influence of the other three knowledge modes (as discussed previously, we did find that organizational knowledge creation as a second-order factor has a significant direct influence on operational capabilities). As a result of these findings, we reject the null hypothesis on H1, H2, and H4. We accept the null hypothesis for H3.

As predicted, results confirmed that organizational knowledge creation (as a second-order factor) has an indirect influence on firm operational performance completely mediated by operational capabilities. Furthermore, results indicate that organizational knowledge creation predicts 27% ($p < .001$) of the variance in firm operational performance when this influence is mediated through operational capabilities – a significant influence (see Table 5-12). Complete mediation through operational capabilities means that organizational knowledge creation has no direct significant influence on firm operational performance (Baron & Kenny, 1986). Consistent with these results, we found that each of the knowledge modes individually has an indirect influence on firm operational performance completely mediated by operational capabilities. Complete mediation through operational capabilities means that each knowledge mode has no direct significant influence on firm operational performance (Baron & Kenny, 1986). Based application of the Baron & Kenny method for testing mediation, we reject the null hypothesis for H5. Table 6-1 summarizes the results of the hypothesis testing.

Table 6-1: Summary of Hypotheses and Results

Hypothesis Number	Hypothesis	Results
H1	Socialization has a positive influence on operational capabilities.	Supported
H2	Combination has a positive influence on operational capabilities.	Supported
H3	Externalization has a positive influence on operational capabilities.	**Not Supported**
H4	Internalization has a positive influence on operational capabilities.	Supported
H5	Operational capabilities mediates a positive relationship between organizational knowledge creation and firm operational performance.	Supported

The results for H5 are consistent with the views of RBT and KBT which posit that for knowledge to significantly influence firm operational performance, organizational knowledge must first be converted to operational capabilities (J. B. Barney, 1986; Grant, 1991; Ray, et al., 2004). Stated another way, organizational knowledge is an input into the value creation process and this value creation is enabled by operational capabilities (Grant, 1996; Schroeder, et al., 2002; Spender, 1996). It has been argued that a firm's operational capabilities is the "missing ingredient" that explains the performance differences among firms (Wu, et al., 2010) and that organizational knowledge creation can lead to the development of operational capabilities (Peng, et al., 2008; Tan, et al., 2007). It has also been established in the literature that operational capabilities can positively influence firm operational performance (J. Barney, 1991; Fugate, et al., 2009; Peng, et al., 2008; Tan, et al., 2007; Wu, et al., 2010). Thus, the results for H5 suggest that these positions in the literature are valid.

The results for H1, H2, and H4, are consistent with the conclusions of Anand (2010) and Mukherjee (1998) who found that process improvement practices can facilitate organizational knowledge creation, which in turn can influence firm performance. From the KBT perspective, firms can translate process knowledge into unique operational capabilities that create superior performance (Kogut & Zander, 1992, p. 396). This is consistent with other scholars who have also argued that process improvement practices can result in the creation of organizational knowledge through formal problem-solving approaches that facilitate rational decision making (Cyert & March, 1963; Nelson & Winter, 1982). Peng (2008) and Tan (2007) both argue that operational capabilities can be developed by process improvement practices. According to (Nonaka, et al., 2006) the dynamic theory of knowledge creation explains the performance difference among firms and, in doing so, provides the building blocks for KBT to better explain the relationship between organizational knowledge creation and firm performance. The results of this study validates the views of these scholars.

We argued that that if organizational knowledge creation can influence operational capabilities as a second-order construct, then it is reasonable to claim that socialization, combination, externalization, and internalization as a sub-factors of organizational knowledge creation can have some direct influence on operational capabilities. With the exception of externalization, the results suggest that this reasoning is correct. In the case of H1, we argued that socialization is capable of creating knowledge independently of the other three knowledge modes. However, Nonaka (1994) points out that "the 'shareability' of knowledge created by pure socialization may be limited and, as a result, difficult to apply in fields beyond specific context in which it was created" (Nonaka, 1994, p. 20). Still, we reasoned that a certain amount of tacit knowledge, even if only localized, could still have some direct influence on operational capabilities. The results suggest that this reasoning is valid. In the case of H2 we reasoned that that once explicit knowledge has been captured and documented, organizational knowledge creation can occur via the coordination of team members across boundaries of a firm and that such organization knowledge is actionable in ways that can influence operational capabilities. The results of this study suggest this reasoning is also valid. In the case of H4 we reasoned that internalization acting in isolation can result in operational experimentation where concepts are articulated in a trial and error way until they are refined enough to put to use. As this explicit knowledge is converted to tacit knowledge via the process of "learning by doing," teams are better able to identify and execute improvements to operations where such improvements can influence operational capabilities. The results suggest that this reasoning is true as well.

In the case of H3, externalization does not have a significant influence on operational capabilities when the influence of the other three knowledge modes is statistically controlled for. According to Nonaka (1994) externalization is the conversion of tacit knowledge into explicit knowledge. Linderman (2010) argues that externalization is often facilitated by metaphors, analogies, concepts, hypotheses, and models that are created by teams when they create concepts triggered by discussion and collective reflection (Linderman 2004, 2010). There may be several possible reasons why externalization had no significant direct influence on operational capabilities. First, the respondent's firms may not have been engaging well or frequently in externalization practices. Second, it is possible that the survey items for externalization did not effectively convey this concept to survey respondents. That is, questions relating to externalization may have had poor content validity.

Third, it may be that the influence of externalization has an effect on the other knowledge modes but does not produce significant knowledge by itself. According to Nonaka (1994), externalization plays a key role in organizational knowledge creation. Each on of the four modes of knowledge creation can create individual knowledge independently. However, organizational knowledge creation “takes place when all four modes of knowledge creation are ‘organizationally’ managed to form a continual cycle” (Nonaka, 1994, p. 20). Therefore, the four modes of knowledge creation work together as a system to generate organizational knowledge. Thus, it is possible that externalization contributes significantly to organizational knowledge creation through its interaction with the other knowledge modes and that this contribution cannot be measured by the direct influence of externalization on operational capabilities.

6.2 Theoretical Contributions

We argue that a missing piece, an area that has been overlooked in the literature, is the mechanism by which organizational knowledge creation (via process improvement practices) develops operational capabilities. It has already been established in the literature that operational capabilities can positively influence firm performance. This study establishes a mediated relationship between organizational knowledge creation and firm performance that has been confirmed by empirical testing. This has several implications for theory.

Scholars have investigated the influence of organizational knowledge creation on firm performance. Anand (2010) found that certain process improvement practices facilitate the creation of organizational knowledge, which can then influence performance outcomes. Cua (2001) found that the use of knowledge-creating practices positively influences manufacturing performance outcomes. Knowledge-creating practices contribute to the performance of firms by creating new process knowledge (Anand, et al., 2010; Shah & Ward, 2003; Zu, et al., 2008). However, these scholars have not fully explained the complete path by which organizational knowledge creation influences firm performance. Rather, these scholars have only theorized about the influence of organizational knowledge on firm performance informed by the dynamic theory of organizational knowledge creation (TKC), RBT and KBT.

Scholars have argued that process improvement practices can develop operational capabilities and that such operational capabilities can influence firm performance (Peng, et al., 2008; Tan, et al., 2007; K. C. Tan, et al., 2004). According to Dosi (2000) operational practices are the building blocks of operational capabilities and individual skills are the building blocks of the practices. However, the aforementioned studies make no explicit mention of the mechanism by which process improvement practices facilitates the creation of organizational knowledge.

Wu (2010) argues that the way a firm's resources are used to achieve superior operational performance is mediated by operational capabilities. That is, operational capabilities is the "missing ingredient" in explaining the performance differences among firms (Wu 2010). Consistent with the findings of Wu (2010), other scholars have also empirically established that operational capabilities influences operational performance (Linderman, et al., 2004; Peng, et al., 2008; Tan, et al., 2007; K. C. Tan, et al., 2004; Wu, et al., 2010). These findings are supported by RBT which takes the perspective that operational capabilities are significant to a firm's success (Colotla, et al., 2003). Management scholars often use RBT to understand the sources of capabilities as a way to explain the performance differences among firms (Peng, et al., 2008). Although there is acceptance that organizational knowledge is a key component of the development of operational capabilities, there is a gap in the literature with respect to the mechanism by which organizational knowledge creation itself can influence operational capabilities.

This study contributes to the literature by empirically establishing the missing piece that the aforementioned studies have not investigated, namely the mechanism or path by which organizational knowledge creation can develop operational capabilities via knowledge-creating practices. This is important because this missing piece adds more conceptual cohesion to these studies paving the way for future studies that will investigate different aspect of the relationships between organizational knowledge creation, operational capabilities, and firm operational performance.

Much of the research pertaining to the influence of organizational knowledge creation on firm performance mediated by a firm's capabilities has been motivated by TKC, RBT and KBT. From the RBT perspective, firms are successful because they are able to acquire and control resources in a productive way which gives the firm performance advantages that cannot easily be imitated by rivals; such inimitability is the result of a firm using proprietary process knowledge to convert resources into capabilities which is not transparent to other firms (J. Barney, 1991; Grant, 1991; Peteraf, 1993). From the KBT perspective, organizational capability is the outcome of knowledge integration; and the linkage between organizational capability and competitive advantage is mediated by this knowledge integration (Grant 1996). Further, "The extent to which a capability is 'distinctive' depends upon the firm accessing and integrating the specialized knowledge of its employees" (Grant 1996, p. 116). Thus, both RBT and KBT support the claim that the influence of organizational knowledge creation on operational performance is mediated by a firm's capabilities. However, the theoretical proposition that organizational knowledge creation influences firm performance has not been empirically tested in the context of process improvement practices.

This research makes a contribution to theory by extending TKC, RBT, and RBT with respect to understanding the role of operational capabilities in mediating the relationship between organizational knowledge creation and firm performance. The findings of this study have two theoretical implications. First, this study adds more depth to the understanding that organizational knowledge is a resource for value creation rather than a business outcome (J. B. Barney, 1986; Grant, 1991; Spender, 1996), which explains why organizational knowledge creation by itself cannot influence firm performance – it must first be converted into operational capabilities (J. B. Barney, 1986; Grant, 1991; Ray, et al., 2004). This is consistent with the views of RBT and KBT that knowledge resources are inputs into the value creation process where certain operational capabilities are a requisite for creating value (Grant, 1996; Schroeder, et al., 2002; Spender, 1996).

Second, the findings of this study fill some of the gaps relating to organizational knowledge creation and firm performance within RBT and KBT. According to Nonaka (1994) the Resource-based Theory does not focus on knowledge, per se, but rather on competences, capabilities, and skills. Further, that the RBT does not address how organizations build competences, capabilities, and skills (Nonaka 1995). Nonaka (2006) has suggested that TKC can explain the performance difference among firms. In doing so, TKC can provide the building blocks for KBT to better explain the influence of organizational knowledge on firm performance. Although TKC does "backfill" a gap in the KBT literature with respect to how organizational knowledge is created, it still does not explain the path by which organizational knowledge is converted into capabilities. The findings of this study adds more depth to TKC which makes it a more useful "building block" for KBT to explain how organizational knowledge creation can influence firm performance.

6.3 Contribution to Practice

For practice, this study offers a better understanding of how knowledge-creating practices can affect firm operational performance. In the context of process improvement, the implication is that firms cannot expect to significantly improve operational performance without facilitating the creation of organizational knowledge via knowledge-creating practices. Many firms have attempted to replicate the practices of other exemplar firms ("best practices") in order to enhance firm performance. However, if such best practices do not produce organizational knowledge, it is likely that the performance results will be marginal to none. This explains, at least in part, why some firms using the same best practices are able to achieve performance gains while many other firms implementing the same best practices in the same industry are not able to achieve significant performance gains. This study highlights the necessity for firms engaged in process improvement to give careful consideration to promoting practices that will facilitate organizational knowledge creation. In doing so, firms will likely achieve more success from their process improvement initiatives.

According to Nonaka (1994) the quality of interaction among workers during process improvement initiatives is only as good as the tacit knowledge that can be captured and converted. As Nonaka (1994) argues, the key to acquiring tacit knowledge is experience – without some form of shared experience, it is extremely difficult for people to share each other' thinking processes" (Nonaka, 1994, p. 20). Process improvement activities provide the context for facilitating shared experiences (Anand, et al., 2010; Linderman, et al., 2004). This suggests that process improvement activities have at least two important roles – 1) developing tacit knowledge within individuals through shared experience, and 2) developing organizational knowledge creation via the formation of knowledge spirals. This also suggests an application to areas such as product development and other organizational disciplines that are associated with knowledge-creating practices.

6.4 Limitations of the Study

This research involves limitations that are inherent to the context as well as the methodology. Contextually, the study has three limitations — it is based on knowledge-creating practices in the context of process improvement, the study targeted manufacturing firms located in the United States, and the respondents are all sourced from one online survey panel. Methodologically, a limitation is that all theoretical constructs are measured at once within the same survey instrument using the same sample.

This study focused on knowledge creating practices in the context of process improvement. However, process improvement is only one of the many organizational disciplines that are associated with knowledge-creating practices. It is possible that other practices may produce different effects on firm operational performance than the practices investigated in this study.

The study targeted manufacturing firms in the United States. This may have implications because the sample is comprised of firms that have certain commonalities with respect to geography. For instance, firms in the U.S. may manage their operation in similar ways, workers may socialize within similar cultural norms, and firm performance may be defined and measured in similar ways. This can be a disadvantage because the results of this study may not be generalizable to cultures that are significantly different from the business culture and norms in the United States.

The respondents for this study all come from a single online survey panel. While the panel includes multiple manufacturing industries and contains a diversity of firm sizes, there may be a certain degree of self-selection in the composition of the survey panel. Further, because the data was gathered over a 10-day time period, we could not test for non-response bias. These issues associated with a single online survey panel present external validity challenges.

Methodologically, a limitation of this research relates to the survey instrument. The study introduces the possibility for mono-method bias (T. D. Cook & Campbell, 1979) because all construct measures are included in the same survey instrument and the data are collected at the same time. Therefore, it is possible that the responses to some survey items might affect the answers to other items because of the way that the items are grouped together on the survey.

6.5 Future Research

This study only investigated knowledge-creating practices associated with process improvement events/activities within manufacturing firms. There are many other kinds of knowledge-creating practices that are implemented in the business context. Possible other areas of research would be to investigate whether other kinds of operational practices can have the same affect on firm performance via operational capabilities. Other areas of research might include — the effect of organizational knowledge creation on product/service innovation, how leadership and organization culture influence organizational knowledge creation, and knowledge-creating practices in the context of collaborating firms — inter firm knowledge creation (i.e., supply chain).

Appendix A1: Survey Instrument

Process Improvement and Firm Performance

About this Survey

Thank you for responding to this survey request.

Many companies use process improvement methodologies like Lean and Six Sigma with the intent to enhance firm performance. Even though companies often replicate the process improvement practices of model companies like Toyota, they do not always achieve significant improvement in firm-level performance -- market share, profitability, growth rate, etc. The reason for this is not clear. Your participation in this survey will help us better understand this problem.

In this survey you will be asked questions about your company such as firm characteristics, process improvement practices, various dimensions of operational capabilities, and competitive firm performance.

For the purpose of this survey **"process improvement"** is defined as a series of actions taken to identify, analyze and improve existing processes within an organization to meet new goals and objectives. These actions often follow a specific methodology or strategy like Lean and/or Six Sigma to create successful results.

To view the Informed Consent for this study click the link below. To go to the survey click the Next button below.

Informed Consent (PDF)

*** Help requests, contact survey@zoompanel.com*

The following questions ask about the characteristics your company. Please select the best answer.

NOTE: All questions must be answered in this survey.

1. Which category best describes your organization? *
(In case more than one category applies, then select the broader category)

- ○ **General Services (Insurance, Financial, Consulting, etc.)**
- ○ **Healthcare**
- ○ **Manufacturing**

- Retail
- Transport & Distribution
- Government
- Education

---

2. What is your primary job role with the company? *
(If more than one role applies, then select the broader role)

- Purchasing
- Human Resource Management
- Executive Management
- Manufacturing Operations
- Sales & Marketing
- Financial or Accounting

---

3. Is the facility(s) that you work at or are responsible for located inside the United States? *

- Yes
- No

***** Help requests, contact survey@zoompanel.com***

These questions ask the extent to which your company is involved in process improvement using methodologies like Lean and Six Sigma. You can also answer "Don't Know".

4. About how long has your company been implementing process improvement? *

- Not yet started
- Less than 1 year
- Between 1 and 3 Years
- Between 3 and 5 years

- More than 5 years
- Don't Know

5. In 2011, about how many process improvements did your company implement? *

- None
- Fewer than 10
- Between 10 and 50
- Between 50 and 100
- More than 100
- Don't Know or N/A

6. How frequently does your company implement process improvements? *

- Weekly
- Monthly
- Quarterly
- Yearly
- Don't Know or N/A

***** Help requests, contact survey@zoompanel.com*

Please rate the extent to which your company engages in the following PROCESS IMPROVEMENT PRACTICES using methodologies like Lean and Six Sigma. Rate on a scale from 1 (Not at all) to 7 (To a great extent). You can also answer "Don't know".

7. There is discussion and/or collaboration among process improvement team members. *
(or discussion among those who "own" process improvement)

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

8. There is discussion between process improvement team members and the ***internal or external customers*** of a process being improved. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

9. There is discussion between improvement team members and the ***internal or external suppliers*** of a process being improved. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

10. We create business case documents that formalize the objectives of process improvement efforts. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

11. We formally and systematically list implied customer requirements (internal and/or external customers). *
(You list what you believe customers want)

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

12. Subjective customer requirements are converted into objective requirements. *
(You formally capture what customers tell you they want)

To a

Not at all ○ ○ ○ ○ ○ ○ ○ To a great extent ○

1 2 3 4 5 6 7 Don't know

13. Data analysis tools and statistical methods are used for process improvement. *

Not at all ○ ○ ○ ○ ○ ○ ○ To a great extent ○

1 2 3 4 5 6 7 Don't know

14. Standard work procedures are *codified* after the completion of process improvement events/activities. *

(In this context, codified means to write down, record, enter into a computer, etc.)

Not at all ○ ○ ○ ○ ○ ○ ○ To a great extent ○

1 2 3 4 5 6 7 Don't know

15. Please answer "Not at All" for this question (for survey calibration purposes). *

Not at all ○ ○ ○ ○ ○ ○ ○ To a great extent ○

1 2 3 4 5 6 7 Don't know

16. Knowledge (lessons learned) from process improvement activities is systematically recorded for future reference. *

Not at all ○ ○ ○ ○ ○ ○ ○ To a great extent ○

1 2 3 4 5 6 7 Don't know

17. Diagrams, charts, forms, process/value stream maps and models are used to facilitate

discussions ***during process improvement events/activities***. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

18. Codified reports are used to initiate discussions *during process improvement about the effectiveness* of the process improvement event/activity. *

(In this context, codified reports are reports that have been recorded, entered into computer, etc.)

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

19. Codified reports are used to generate discussions about the *results after the completion of process improvement events/activities.* *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

***** Help requests, contact survey@zoompanel.com***

The next series of questions are about various aspects of your company's operational capabilities.

The following three questions are about your company's capabilities in the area of operational IMPROVEMENT using tools like Lean and Six Sigma. Please rate the extent to which your company does the following on a scale from 1 (Not at all) to 7 (To a great extent). You can also answer "Don't know".

20. We continually standardize our production processes. *

(For example, standardize procedures, machinery, equipment, workflow, etc.)

To a

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

21. We continually eliminate waste and/or unwanted variance from our production processes. *
(Waste includes unnecessary time, motion, inventory, waiting, rework, etc.)

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

22. Based on our experience, we improve our processes continually rather than on an ad hoc basis. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

***** Help requests, contact survey@zoompanel.com***

The following three questions are about your company's capabilities in the area of operational INNOVATION. Please rate the extent to which your company does the following on a scale from 1 (Not at all) to 7 (To a great extent). You can also answer "Don't know".

NOTE: Process innovation or radical improvement as used below means to re-engineer an entire process at one time rather than incrementally improving it.

23. We have created process innovations *that made our prevailing processes obsolete*. *
(The previous process was replaced.)

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

24. We have created process innovations that ***made existing EXPERTISE in the prevailing processes obsolete***. *

(The expertise or knowledge associated with the previous process was no longer applicable)

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

25. We have created process innovations ***that fundamentally changed our prevailing processes*** . *

(Process innovations in some part of a process significantly changed {but not replaced} the larger process)

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

***** Help requests, contact survey@zoompanel.com***

The following four questions are about your company's capabilities in the area of operational CUSTOMIZATION. Please rate the extent to which your company does the following on a scale from 1 (Not at all) to 7 (To a great extent). You can also answer "Don't know".

26. We use our ***production equipment*** in unique ways to differentiate us from our competitors. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

27. Our ***production processes*** have been modified and/or extended to gain unique or superior positions in the market. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

28. Our *product design process* has been modified and/or extended to better serve the needs of our customers. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

29. Our *planning systems* have been modified and/or extended to better serve the needs of our customers. *
(For example, your Sales and Operations Planning process)

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

***** Help requests, contact survey@zoompanel.com***

The following three questions are about your company's capabilities in the area of operational COOPERATION. Please rate the extent to which your company does the following on a scale from 1 (Not at all) to 7 (To a great extent). You can also answer "Don't know".

30. Our information system facilitates cooperation across company functions (i.e., production, purchasing, sales, etc). *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

31. Our standard operating procedures facilitate teamwork across company functions. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

32. Our employees collaborate with each other across company functions to diagnose and solve process problems. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

***** Help requests, contact survey@zoompanel.com***

The following three questions are about your company's capabilities in the area of operational RESPONSIVENESS. Please rate the extent to which your company does the following on a scale from 1 (Not at all) to 7 (To a great extent). You can also answer "Don't know".

33. We can quickly change the route of a job flow when production equipment availability becomes a problem. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

34. We can easily accommodate unexpected variations in *supply* such as components and other material inputs. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

35. Please answer "To a Great Extent" for this question (for survey calibration purposes). *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

36. We can easily accommodate unexpected variations in *production labor* requirements. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

***** Help requests, contact survey@zoompanel.com***

The following three questions are about your company's capabilities in the area of operational RECONFIGURATION. Please rate the extent to which your company does the following on a scale from 1 (Not at all) to 7 (To a great extent). You can also answer "Don't know".

37. We *adopt better practices* to respond to market changes. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't know

38. We *reconfigure or combine resources* in different ways to respond to market changes. *

Not at all	○	○	○	○	○	○	○	To a great extent	○
	1	2	3	4	5	6	7		Don't

know

39. We develop *new competences and skills* to respond to market changes. *

Not at all	○	○	○	○	○	○	○	**To a great extent**	○
	1	2	3	4	5	6	7		Don't know

**** Help requests, contact survey@zoompanel.com***

The next series of questions ask your opinion about various aspects (cost, product quality, delivery, flexibility) of your company's operational performance relative to competitors .

Please rate the COST PERFORMANCE of your company's manufacturing operation relative to competitors . Rate from -3 (Much Less) to +3 (Much More) relative to competitors. You can also answer "Don't know".

40. Manufacturing unit cost. *
(Direct labor and materials used to manufacture a product)

Much Less	○	○	○	○	○	○	○	**Much More**	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

41. Manufacturing overhead costs. *
(For example, indirect labor, indirect materials and supplies, utilities, material handling, and depreciation on equipment and facilities)

Much Less	○	○	○	○	○	○	○	**Much More**	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

42. Total cost of operations (includes supply acquisition, setup, maintenance, service, etc.) *

(Includes direct and indirect costs as well as other costs such as supply acquisition, setup, maintenance, office support personnel, etc.)

Much Less	-3	-2	-1	About the Same	+1	+2	+3	**Much More**	Don't know

***** Help requests, contact survey@zoompanel.com***

Please rate your PRODUCT QUALITY relative to competitors . Rate from -3 (Much Worse) to +3 (Much Better) relative to competitors. You can also answer "Don't know".

43. Product conformance to established standards. *

Much Worse	-3	-2	-1	About the Same	+1	+2	+3	**Much Better**	Don't know

44. Product durability. *

Much Worse	-3	-2	-1	About the Same	+1	+2	+3	**Much Better**	Don't know

45. Product reliability. *

Much Worse	-3	-2	-1	About the Same	+1	+2	+3	**Much Better**	Don't know

46. Product features. *

Much Worse	○	○	○	○	○	○	○	**Much Better**	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

47. Overall product quality. *

Much Worse	○	○	○	○	○	○	○	**Much Better**	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

***** Help requests, contact survey@zoompanel.com***

Please rate your company's DELIVERY PERFORMANCE relative to competitors . Rate from -3 (Much Worse) to +3 (Much Better) relative to competitors. You can also answer "Don't know".

48. On time delivery. *

Much Worse	○	○	○	○	○	○	○	**Much Better**	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

49. Delivery dependability (consistency). *

Much Worse	○	○	○	○	○	○	○	**Much Better**	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

50. Delivery quality (as ordered and completeness). *

Much Worse	○	○	○	○	○	○	○	**Much Better**	○

	-3	-2	-1	About the Same	+1	+2	+3		Don't know

***** Help requests, contact survey@zoompanel.com***

Please rate the FLEXIBILITY of your company's manufacturing operation <u>relative to competitors</u> . Rate from -3 (Much Worse) to +3 (Much Better) <u>relative to competitors.</u> You can also answer "Don't know".

51. Ability to adjust product volume in response to changes in market conditions. *

Much Worse	○	○	○	○	○	○	○	**Much Better**	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

52. Please answer "Much Better" for this question (for survey calibration purposes). *

Much Worse	○	○	○	○	○	○	○	**Much Better**	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

53. Ability to manufacture a range of products using the same equipment and/or production line. *

Much Worse	○	○	○	○	○	○	○	**Much Better**	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

***** Help requests, contact survey@zoompanel.com***

These next questions ask your opinion about your company's overall FINANCIAL AND

SERVICE PERFORMANCE (firm level) relative to competitors.

Please rate your company's performance on the following dimensions relative to competitors. Rate from -3 (Much Worse OR Much Less) to +3 (Much Better OR Much More). You can also answer "Don't know".

54. Return on total assets. *
(Reflects how productively all assets are used to generate revenue)

Much Less	○	○	○	○	○	○	○	Much More	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

55. Profitability. *

Much Less	○	○	○	○	○	○	○	Much More	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

56. Current market share. *

Much Less	○	○	○	○	○	○	○	Much More	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

57. Sales growth rate. *

Much Worse	○	○	○	○	○	○	○	Much Better	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

58. Overall customer service. *

Much Worse	○	○	○	○	○	○	○	Much Better	○

	-3	-2	-1	About the Same	+1	+2	+3		Don't know

59. Competitive position in your industry/market. *

Much Worse	○	○	○	○	○	○	○	**Much Better**	○
	-3	-2	-1	About the Same	+1	+2	+3		Don't know

***** Help requests, contact survey@zoompanel.com***

These next questions ask you some general questions about your company.

60. Is your company privately held or a publicly-traded company? *

- ○ **Private**
- ○ **Public**

61. Is your company unionized? *

- ○ **Yes**
- ○ **No**

62. How many employees does your company have? *

- ○ **Less than 100**
- ○ **Less than 250**
- ○ **Less than 500**
- ○ **More than 500**

63. What type of manufacturing does your company do? *

- ○ **Discrete Manufacturing (i.e., cars, machines, electronics, etc)**

○ **Process or Continuous Manufacturing (i.e., food, petroleum, chemicals, etc.)**

64. Do you have an employee(s) whose full-time job is to implement and/or direct process improvements within your company? *

○ **Yes**

○ **No**

***** Help requests, contact survey@zoompanel.com***

Please rate your level of agreement or disagreement on the following questions.

65. Any manufacturing company can apply process improvement methodologies like Lean and/or Six Sigma to improve firm performance. *
(Assume effective implementation)

Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
○	○	○	○	○

66. The competitive performance of my company has improved due the application of Lean and/or Six Sigma. *
(Competitive performance as measured by market share, profitability, revenue growth rate, etc.)

Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
○	○	○	○	○

***** Help requests, contact survey@zoompanel.com***

New Page

Thank you for taking our survey! Your participation is very much appreciated.

If you wish to receive a copy of the results of this study, please email your request to mjordan6@student.gsu.edu. A copy of the results will be emailed to you at no cost.

Appendix A2: Survey Filter logic

Filter#	IF condition is true, then redirect respondent back to Zoomerang
1	**IF** The answer to Question #1 is in list General Services, Healthcare, Retail, Transport & Distribution, Government or Education **OR** The answer to Question #2 is in list Purchasing, Human Resource Management, Sales & Marketing or Financial or Accounting
2	**IF** The answer to Question #4 is in list “Not yet started” or “Don't Know” **OR** The answer to Question #5 is exactly equal to “None”
3	**IF** The answer to Question #7 is exactly equal to “Don't know” **AND** The answer to Question #8 is exactly equal to “Don't know” **AND** The answer to Question #9 is exactly equal to “Don't know” **AND** The answer to Question #10 is exactly equal to “Don't know” **OR** The answer to Question #15 is in list 2, 3, 4, 5, 6, 7 or “Don't know”
4	**IF** The answer to Question #20 is exactly equal to “Don't know” **AND** The answer to Question #21 is exactly equal to “Don't know”
5	**IF** The answer to Question #23 is exactly equal to “Don't know” **AND** The answer to Question #24 is exactly equal to “Don't know” **AND** The answer to Question #25 is exactly equal to “Don't know”
6	**IF** The answer to Question #26 is exactly equal to “Don't know” **AND** The answer to Question #28 is exactly equal to “Don't know” **AND** The answer to Question #29 is exactly equal to “Don't know”
7	**IF** The answer to Question #30 is exactly equal to “Don't know” **AND** The answer to Question #32 is exactly equal to “Don't know”

8	**IF** The answer to Question #33 is exactly equal to "Don't know" **AND** The answer to Question #34 is exactly equal to "Don't know" **AND** The answer to Question #36 is exactly equal to "Don't know" **OR** The answer to Question #35 is in list 1, 2, 3, 4, 5, 6 or "Don't know"
9	**IF** The answer to Question #40 is exactly equal to "Don't know" **AND** The answer to Question #41 is exactly equal to "Don't know" **AND** The answer to Question #42 is exactly equal to "Don't know"
10	**IF** The answer to Question #43 is exactly equal to "Don't know" **AND** The answer to Question #44 is exactly equal to "Don't know" **AND** The answer to Question #45 is exactly equal to "Don't know"
11	**IF** The answer to Question #48 is exactly equal to "Don't know" **AND** The answer to Question #49 is exactly equal to "Don't know" **AND** The answer to Question #50 is exactly equal to "Don't know"
12	**IF** The answer to Question #52 is in list -3, -2, -1, "About the Same," +1, +2 or "Don't know"

Appendix B1: Descriptive Statistics (Normalization Analysis)

Statistics

		SOC2	SOC3	EXT2	EXT3	COM1	COM3	INT2	INT3	IMP1
N	Valid	172	170	169	170	171	171	170	171	172
	Missing	0	2	3	2	1	1	2	1	0
Mean		5.08	5.08	5.49	5.36	5.56	5.53	5.09	5.27	5.60
Std. Error of Mean		.107	.109	.108	.104	.116	.103	.122	.119	.105
Median		5.00	5.00	6.00	6.00	6.00	6.00	5.00	6.00	6.00
Mode		5	5	6	6	7	6	6	6	7
Std. Deviation		1.402	1.427	1.398	1.361	1.519	1.343	1.596	1.561	1.375
Variance		1.965	2.036	1.954	1.853	2.307	1.804	2.547	2.436	1.891
Skewness		-.716	-.631	-1.021	-.760	-1.101	-.750	-.863	-.993	-.926
Std. Error of Skewness		.185	.186	.187	.186	.186	.186	.186	.186	.185
Kurtosis		.269	.134	.711	.156	.562	-.346	.013	.199	.270
Std. Error of Kurtosis		.368	.370	.371	.370	.369	.369	.370	.369	.368
Range		6	6	6	6	6	5	6	6	6

Statistics

		IMP2	IMP3	INN1	INN2	CUS1	CUS2	COO1	COO2	COO3
N	Valid	172	171	172	171	171	169	171	171	171
	Missing	0	1	0	1	1	3	1	1	1
Mean		5.56	5.58	4.74	4.39	5.02	5.43	5.55	5.49	5.40
Std. Error of Mean		.102	.103	.117	.119	.121	.104	.101	.103	.120
Median		6.00	6.00	5.00	4.00	5.00	6.00	6.00	6.00	6.00
Mode		6[a]	6	5	4	5	6	6	6	6
Std. Deviation		1.343	1.341	1.528	1.551	1.583	1.353	1.320	1.348	1.574
Variance		1.804	1.797	2.335	2.404	2.505	1.830	1.743	1.816	2.477
Skewness		-.880	-1.191	-.515	-.274	-.570	-1.088	-1.048	-.866	-1.066
Std. Error of Skewness		.185	.186	.185	.186	.186	.187	.186	.186	.186
Kurtosis		.181	1.212	-.354	-.562	-.219	1.221	.897	.240	.540
Std. Error of Kurtosis		.368	.369	.368	.369	.369	.371	.369	.369	.369
Range		5	6	6	6	6	6	6	6	6

Statistics

		RES1	RES2	RES3	REC1	REC2	REC3	COS1	COS2	COS3
N	Valid	172	171	172	171	171	171	171	169	168
	Missing	0	1	0	1	1	1	1	3	4
Mean		4.90	4.73	4.86	5.50	5.44	5.44	-.23	-.28	-.24
Std. Error of Mean		.120	.113	.106	.095	.095	.105	.108	.108	.108
Median		5.00	5.00	5.00	6.00	6.00	6.00	.00	.00	.00
Mode		5	4	6	6	6	6	0	-1	-1
Std. Deviation		1.577	1.475	1.391	1.238	1.242	1.377	1.407	1.398	1.398
Variance		2.487	2.177	1.934	1.534	1.542	1.895	1.980	1.955	1.955
Skewness		-.496	-.516	-.473	-.787	-1.176	-1.073	.014	.189	.154
Std. Error of Skewness		.185	.186	.185	.186	.186	.186	.186	.187	.187
Kurtosis		-.496	-.147	-.417	.196	1.535	.570	-.553	-.375	-.341
Std. Error of Kurtosis		.368	.369	.368	.369	.369	.369	.369	.371	.373
Range		6	6	6	5	6	6	6	6	6

Statistics

		QPE1	QPE2	QPE3	QPE4	QPE5	DEL1	DEL2	FLE1	FLE2
N	Valid	172	171	171	172	172	172	172	170	172
	Missing	0	1	1	0	0	0	0	2	0
Mean		1.54	1.64	1.73	1.56	1.84	1.44	1.47	1.23	1.45
Std. Error of Mean		.095	.093	.098	.089	.088	.094	.092	.088	.100
Median		2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.00	2.00
Mode		2[a]	2	3	3	2[a]	2	2	1[a]	2
Std. Deviation		1.239	1.216	1.279	1.166	1.148	1.234	1.211	1.141	1.313
Variance		1.536	1.478	1.636	1.359	1.318	1.522	1.467	1.302	1.723
Skewness		-.448	-.657	-.956	-.243	-.896	-.579	-.391	-.147	-.604
Std. Error of Skewness		.185	.186	.186	.185	.185	.185	.185	.186	.185
Kurtosis		-.760	-.310	.550	-.954	.197	.016	-.656	-.665	-.128
Std. Error of Kurtosis		.368	.369	.369	.368	.368	.368	.368	.370	.368
Range		5	5	6	5	5	6	5	5	6

Statistics

		QAL5	QAL10	QAL11	QAL12	QAL13	QAL14	SOC_X	EXT_X	COM_X
N	Valid	157	172	172	172	172	172	170	168	170
	Missing	15	0	0	0	0	0	2	4	2
Mean		2.01	1.44	.31	3.06	1.39	.73	5.082	5.426	5.535
Std. Error of Mean		.080	.038	.035	.091	.037	.034	.1013	.0971	.0986
Median		2.00	1.00	.00	4.00	1.00	1.00	5.000	5.500	6.000
Mode		2	1	0	4	1	1	5.0	5.5	5.5
Std. Deviation		1.006	.497	.465	1.198	.489	.447	1.3209	1.2581	1.2855
Variance		1.013	.247	.217	1.435	.239	.200	1.745	1.583	1.653
Skewness		.815	.260	.809	-.774	.457	-1.027	-.730	-.850	-.967
Std. Error of Skewness		.194	.185	.185	.185	.185	.185	.186	.187	.186
Kurtosis		-.361	-1.955	-1.362	-1.062	-1.812	-.957	.714	.173	.355
Std. Error of Kurtosis		.385	.368	.368	.368	.368	.368	.370	.373	.370
Range		3	1	1	3	1	1	6.0	5.5	5.0

Statistics

		INT_X	IMP_X	INN_X	CUS_X	COO_X	RES_X	REC_X	COS_X	QPE_X
N	Valid	170	171	171	169	170	171	171	168	171
	Missing	2	1	1	3	2	1	1	4	1
Mean		5.194	5.581	4.558	5.234	5.486	4.825	5.464	-.250	1.661
Std. Error of Mean		.1165	.0915	.1065	.1025	.0969	.0996	.0909	.0970	.0810
Median		5.500	6.000	4.500	5.500	5.667	5.000	5.667	-.333	1.800
Mode		6.0	6.0	4.0	5.0	5.7[a]	5.7	6.0	-.7	3.0
Std. Deviation		1.5193	1.1966	1.3931	1.3319	1.2640	1.3022	1.1884	1.2572	1.0590
Variance		2.308	1.432	1.941	1.774	1.598	1.696	1.412	1.581	1.121
Skewness		-.944	-1.052	-.444	-.823	-1.017	-.491	-1.115	.112	-.757
Std. Error of Skewness		.186	.186	.186	.187	.186	.186	.186	.187	.186
Kurtosis		.164	.715	-.138	.627	.596	-.182	.978	-.315	.020
Std. Error of Kurtosis		.370	.369	.369	.371	.370	.369	.369	.373	.369
Range		6.0	5.3	6.0	6.0	5.3	6.0	5.7	6.0	4.8

Statistics

		DEL_X	FLE_X	KNOW	OPCAP	OPPER
N	Valid	172	170	163	167	166
	Missing	0	2	9	5	6
Mean		1.453	1.347	5.327	5.181	1.055
Std. Error of Mean		.0890	.0814	.0882	.0759	.0568
Median		1.500	1.500	5.500	5.306	1.088
Mode		2.0	2.0	5.4[a]	4.9[a]	.4
Std. Deviation		1.1676	1.0618	1.1260	.9805	.7319
Variance		1.363	1.127	1.268	.961	.536
Skewness		-.544	-.245	-.883	-.775	-.114
Std. Error of Skewness		.185	.186	.190	.188	.188
Kurtosis		-.229	-.474	.637	.615	-.121
Std. Error of Kurtosis		.368	.370	.378	.374	.375
Range		5.0	4.5	5.4	5.3	3.9

a. Multiple modes exist. The smallest value is shown

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