Paper:
Bortolotti, T., Danese, P., Flynn, B. & Romano, P. (2014). Leveraging fitness and lean bundles to build the cumulative performance sand cone model. *International Journal of Production Economics, 162*, 227-241.

http://dx.doi.org/10.1016/j.ijpe.2014.09.014

Bortolotti T., Danese P., Flynn B.B., Romano P. (2015). Leveraging fitness and lean bundles to build the cumulative performance sand cone model. INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS, vol. 162, pp. 227–241, doi:10.1016/j.ijpe.2014.09.014.

Leveraging fitness and lean bundles to build the cumulative performance sand cone model ☆

Thomas Bortolotti[a], Pamela Danese[b], Barbara B. Flynn[c], Pietro Romano[d]

[a] School of Management, Swansea University, Singleton Park, Swansea SA2 8PP, UK
[b] Department of Management and Engineering, University of Padova, Stradella S. Nicola, 3, Vicenza 36100, Italy
[c] Richard M. and Myra Louise Buskirk Professor of Manufacturing Management, Kelley School of Business, Indiana University, 801 W. Michigan St., Indianapolis, IN 46202, United States
[d] Department of Electrical, Managerial and Mechanical Engineering, University of Udine, Via delle Scienze, 208, Udine 33100, Italy

☆ This article was selected from papers presented at the 4th World Conference on Production and Operations Management (P&OM Amsterdam 2012), co-organized by the European Operations Management Association (EurOMA), The Production and Operations Management Society (POMS) and the Japanese Operations Management and Strategy Association (JOMSA). The original paper has followed the standard review process for the International Journal of Production Economics. The process was managed by Jose A.D. Machuca (POMS-EurOMA) and Andreas Groessler (EurOMA) and supervised by Bartholomew McCarthy (IJPE's Editor Europe). The Conference paper was an exequo winner of the Jose A.D. Machuca best paper POM World Conference Award.

Abstract

This study examines the relationship between bundles of lean practices and cumulative performance, as described by the sand cone model. Based on the literature, hypotheses relating lean bundles to cumulative performance are proposed. They are tested using a sample of 317 plants in three industries and ten countries, based on structural equation modeling. The results indicate a set of direct and indirect relationships that illustrate: (1) the importance of organizational fitness at the base of the sand cone of practices, (2) the cumulative relationship of competitive performance, supporting the sand cone model, and (3) the cumulative relationship between lean bundles and the sand cone sequence of cumulative performance. Testing alternative models of cumulative performance lends further support to these results. The findings are discussed in terms of implications for managers seeking guidance in competing on multiple dimensions of competitive performance simultaneously, particularly in terms of establishing a foundation of organizational fitness for the cumulative implementation of lean bundles. It contributes to the literature on manufacturing strategy and lean by providing additional support for the sand cone of cumulative performance, expanding research on the sand cone of practices that support cumulative performance, describing the role that external resources like suppliers can play in mastering lean cumulatively and separating previous research on lean bundles into those related to fitness and those with a more specific goal orientation, building on the strong foundation provided by the extended resource based view and the concept of absorptive capacity.

Keywords

- Sand cone model;
- Cumulative performance;
- Lean manufacturing;
- Operations strategy

1. Introduction

The sand cone model of cumulative performance (Ferdows and De Meyer, 1990) has been an enduring and popular element of operations strategy for many years. Its empirical support has been somewhat mixed; however, there is general agreement that there are benefits to using strength in one dimension of competitive performance as the foundation for improving others. There has been less research, however, on how to achieve cumulative performance. Which practices support cumulative performance? For example, is there a particular sequence of practices that will support it?

We propose that what differentiates the best performers is their adherence to a sand cone of specific practices, supported by a broad infrastructure. The concept of organizational fitness is key in explaining the role of infrastructure. Employing a sports metaphor, Ferdows and Thurnheer (2011) describe the general training that athletes undertake to develop their speed, agility and strength, in addition to the more specific training that is related to their particular sports. Having a foundation of general fitness allows them to better develop the specific skills that they need for their particular sports. Similarly, a firm that is fit will be better able to develop specific capabilities that are related to the particular dimensions of competitive performance it has chosen to pursue. Thus, we propose that fitness should be at the bottom of a sand cone of practices, providing an infrastructure for more specific practices.

We begin by reviewing the literature on cumulative performance and how it is expected to provide a competitive advantage that is difficult to imitate. We then operationalize the fitness construct and describe its role in a sand cone sequence of practices that is based on Shah and Ward, 2003 and Shah and Ward, 2007 work on bundles of lean practices. Hypotheses are tested using a sample of manufacturing firms in ten countries. We conclude by describing managerial implications and future research opportunities in this interesting stream of research.

2. Literature review

2.1. Cumulative performance

The cumulative performance perspective was developed in reaction to the tradeoffs perspective of competitive performance, originally articulated by Skinner (1969) and elaborated upon by numerous researchers in strategic management and operations strategy, including Porter, 1981 and Porter, 1985), Hayes and Wheelwright (1984), Kotha and Orne (1989), Dess and Davis (1984), Robinson and Pearce (1988), Hayes and Pisano (1994), and Clark (1996). Porter (1981) refers to the simultaneous pursuit of multiple dimensions of competitive performance as a 'recipe for mediocrity,' causing firms to become 'stuck in the middle.' More recently, however, the notion of tradeoffs has been challenged by both theoretical perspectives (Schmenner and Swink, 1998 and Rosenzweig and Roth, 2004) and empirical evidence (Chen and Paulraj, 2004,Boyer and Lewis, 2002, Flynn and Flynn, 2005, Corbett and Whybark, 2001, Narasimhan and Schoenherr, 2013 and Narasimhan et al., 2005). Rosenzweig and Easton's (2010)meta-analysis of two decades of research on this topic found that there was 'overwhelming evidence' that manufacturers were not reporting the tradeoffs that are described by this perspective.

In contrast, there has been a substantial amount of research related to high performance on multiple dimensions of competitive performance simultaneously, in both the operations management literature (Schonberger, 1986, New, 1992 and Hayes and Pisano, 1994; Flynn and Flynn, 2005) and the strategic management literature (Hall, 1980, Hambrick, 1983, Phillips et al., 1984, White, 1996, Jones and Butler, 1988 and D'Aveni, 1994). By capitalizing on synergies between practices, the best firms create a sustainable competitive advantage that is difficult for competitors to challenge (New, 1992). A number of authors have described how addressing dimensions of performance in a particular sequence lays the foundation for improvements in other dimensions (Hall and Nakane, 1990, Corbett and Van Wassenhove, 1993, Swink and Way, 1995 and Schmenner and Swink, 1998).

2.2. The sand cone model

There has been a substantial amount of literature devoted to Ferdows and De Meyer's (1990) sand cone model, which is a particular instance of the cumulative performance construct. It describes how the best firms strive to improve in particular dimensions of performance in sequence and only as previous performance dimensions are further developed. Fig. 1 illustrates that quality performance forms the base of the sand cone. Delivery performance is built upon the foundation of quality performance, and, as delivery performance is developed, the quality base continues to expand. Similarly, flexibility performance is built on the foundation of quality and delivery performance. As cost performance is layered on the top of the sand cone, the foundation of quality, delivery and flexibility performance continues to expand.

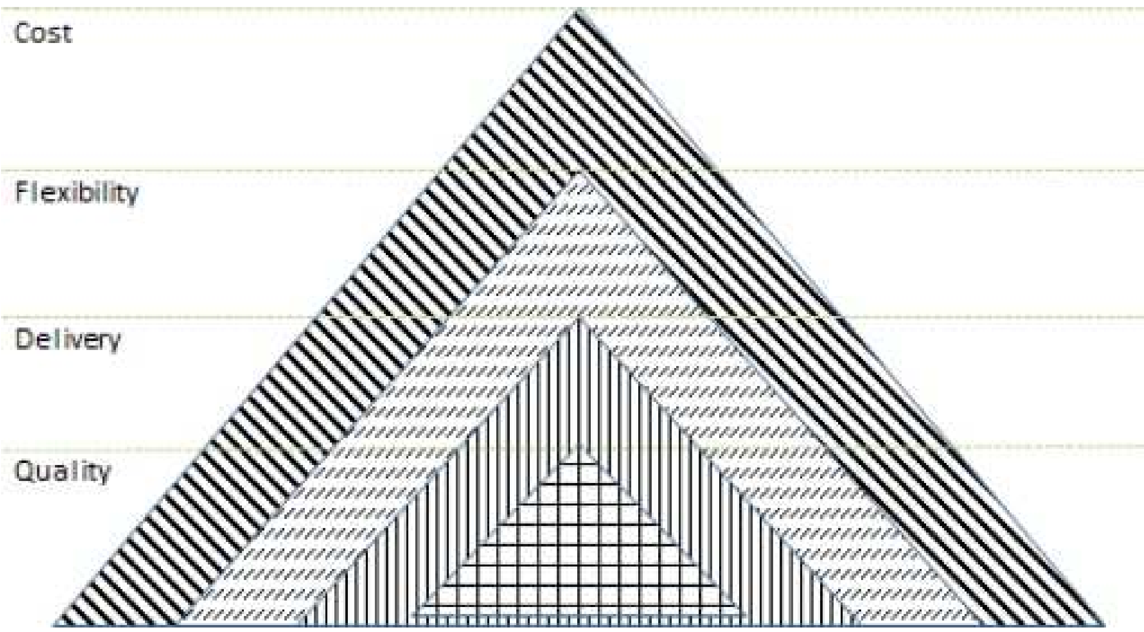

Fig. 1. Sand cone model of cumulative performance.

Although the sand cone model is widely cited, intuitively appealing and supported by anecdotal evidence from a variety of sources, its empirical support has been limited (seeTable 1).

Table 1. Summary of prior key research on cumulative performance.

Authors	Cumulative capabilities	Competitive priorities	Sequence	Results
Amoako-Gyampah and Meredith (2007)		X	Quality, cost; delivery, flexibility	Evidence for the cumulative model, with cost as the second level
Boyer and Lewis (2002)		X	Quality, delivery, flexibility, cost	Tradeoffs remain, but plants increasing consider all four vital. A halo effect between competitive priorities
Corbett and Whybark (2001)	X		Quality, delivery, flexibility, cost	Limited evidence supporting the sand cone model
Ferdows and De Meyer (1990)	X		Quality, delivery, flexibility, cost	Introduced sand cone sequence of cumulative performance
Flynn and Flynn (2004)	X		Varied by country	Cumulative model not supported; substantial differences in cumulative capability sequences across countries; limited evidence of industry differences
Größler and Grübner (2006)	X		Quality, delivery, flexibility, cost	Evidence of cumulative effects
Nakane (1986)	X		Quality, delivery, cost, flexibility	Cost as an intermediate dimension
Noble (1995)	X		Quality, dependability, delivery, cost efficiency, flexibility, innovation	Preliminary evidence for the cumulative model, with some different managerial approaches across countries
Rosenzweig and Roth (2004)	X		Quality, delivery, flexibility, cost	Evidence supporting the sand cone model sequence
Safizadeh et al. (2000)	X		Quality, delivery, customization, cost	Improving quality goes together with improving delivery
Schroeder et al. (2011)	X		Quality, delivery, flexibility, cost	The sequence of capabilities depends on contingent factors

2.3. Achievement of cumulative performance

The theoretical underpinnings for cumulative performance build on synergies between practices. Narasimhan et al. (2005) note the contrast between the numerous studies of sequences of cumulative performance with the absence of analogous studies of progression in manufacturing practices. Rosenzweig and Roth (2004) attribute these synergies to accelerated learning, drawing upon the knowledge- based view of the firm (Grant and Baden-Fuller, 1995). Although successive stages require increasingly higher levels of process integration and coordination, mastery of the prior stages develops operational know-how. This ever-expanding base of operational know-how facilitates acquisition and assimilation of the new knowledge required for the next level (Rosenzweig and Roth, 2004). For example, TQM can help a firm accelerate its learning as it adapts TQM practices to its unique history and the problems that it faces.

2.3.1. Sand cone of lean practices

Lean manufacturing practices are often conceptually associated with strength in multiple dimensions of competitive performance simultaneously; however, the empirical findings about lean in this context are mixed. Schroeder et al. (2011) mapped bundles of lean practices to corresponding sand cone dimensions, but did not find a consistent relationship, while Flynn and Flynn (2004) only found empirical support for the lower levels of a sand cone of lean practices. Voss (2003) conceptually adapted the concept of the sand cone model to e-service practices, beginning with a foundation of general service at the base.

We suggest that the failure to find support for a sand cone sequence of practices may be due to attempting to directly link practices with the sand cone performance sequence in a one-to-one manner, beginning with quality practices as the foundation. Like Voss (2003), we recognize that there is a foundation of general practices that should be developed as the foundation for the practices that are targeted at specific types of performance. The notion of a supporting infrastructure was described by Ferdows and Thurnheer (2011) as “fitness,” which we propose as providing the foundation for sequential development of practices in support of the sand cone model; failing to start with an appropriate level of fitness may compromise the potential of bundles of TQM and JIT practices.

2.3.2. Fitness as the base

Ferdows and Thurnheer (2011) describe fitness as providing a foundation for building more specific practices. Using a sports metaphor, they differentiate between fitness and leanness. While fitness builds muscles and agility in a general sense, leanness focuses on taking the fat out. Athletes train using similar routines to improve their agility, strength and stamina, no matter what their individual sports are. Thus, football, basketball and rugby players may all do sit-ups and run laps to build muscle and stamina, which they develop as the foundation for skills in their particular sport. However, taking the fat out without a foundation of general strength and stamina can be counterproductive for an athlete. Similarly, a manufacturer that focuses only on lean without first developing a foundation of fitness runs the risk of becoming fragile (Ferdows and Thurnheer, 2011), as illustrated by examples of lean firms that have run into serious difficulties when faced with supply chain disruptions.

For example, the March, 2000 fire at a Philips Electronics plant in Albuquerque, New Mexico caused a severe disruption in the chip supply to a number of cell phone companies, including Nokia Corp. and Ericsson (Sheffi and Rice, 2005). Nokia and Ericsson experienced very different outcome, due to differences in their fitness. Nokia was able to respond very aggressively to news of the fire, sending 30 employees to work with Philips to attempt to restore the source of its supply. It also drew upon its relationships with other chip suppliers, in order to ensure that its worldwide chip capacity would remain intact, immediately negotiating contracts with them. Ericsson, on the other hand, was slow to perceive the seriousness of the problem. By the time it searched for alternative chip suppliers, their capacity was already committed to Nokia. Because Ericsson had taken the fat out when it implemented lean, by eliminating seemingly unnecessary supplier relationships and developing a strategy that did not include the importance of strategic supply chain issues, it was unable to compensate for this disruption, resulting in its missing a critical new product introduction, with an estimated $400 million loss in revenue. Nokia's fitness, on the other hand, is described in the following quote:

Observers have attributed Nokia′'s resilience in large part to the company's culture of*sisu*, which is Finnish for "curtness under pressure," or simply "guts." That ethos, along with Nokia's deep relationships with its suppliers, enabled the company to recognize the severity of the situation quickly, disseminate the news and take immediate action at various levels of the organization, from the CEO on down (Sheffi and Rice, 2005, p. 48).

Without a strategic commitment to supply chain management from its highest levels, a strong human resource strategy and tight relationships with a wide variety of suppliers, Nokia would have suffered the same fate as Ericsson.

Another example of fitness is the story of UPS's Louisville, Kentucky hub (Sheffi and Rice, 2005). When it was shut down by an unexpectedly severe blizzard in 1994, the city closed all roads and instituted a travel ban for a week. Although the airport reopened, the local travel ban prevented UPS employees from reporting to work, leaving millions of packages stranded at the airport. UPS solved the problem by flying in employees from around the country to do the processing, which was made possible because its human resources were familiar with the processes, which were similar at all locations, and could operate any of them (Sheffi and Rice, 2005).

Fitness allows a firm to respond more quickly and efficiently when the market demands something different, because it has already developed more of the requisite skills than its competitors that focus exclusively on lean. Because it develops what appear to be unrelated capabilities, a fit manufacturer has more capabilities than it needs to meet its current competitive priorities (Ferdows and Thurnheer, 2011). For example, Nokia had developed relationships with many suppliers that it didn't have an immediate need for, and UPS had trained local employees to be flexible enough to work in any of its facilities. These seemingly unrelated capabilities strengthen a company's "means" beyond the boundaries of specific "ends" (Hayes and Wheelwright, 1984), creating a virtuous cycle. As a plant develops multiple capabilities, it becomes more agile to respond to changing market mandates, because it can move in a number of directions, allowing further development of a variety of capabilities.

Thus, fitness adds an important dynamic dimension to lean. A fit manufacturer has a foundation of strong practices that allow it to stay lean under changing circumstances and over longer periods of time, making it adaptable to a dynamic environment. Ferdows and Thurnheer (2011) emphasize that fitness isn't a substitute for lean, but rather a complement that facilitates lean. Although it may take it longer to achieve a particular competitive advantage, building lean on a foundation of fitness develops a competitive advantage that is difficult to imitate, because competitors tend to focus on the more visible lean practices, which are imperfectly imitable without their fitness foundation.

2.3.3. Key fitness capabilities

The question, then, is what sorts of capabilities are important to fitness? According toFerdows and Thurnheer (2011), fitness is based on general attributes related to agility, strength and stamina. In thinking about how to operationalize fitness, we considered general bundles of practices related to organizational agility, strength and stamina. Using lean practices as a starting point, we examined Shah and Ward's (2003) bundles of lean practices. We argue that their four lean bundles actually serve two different purposes. We posit that two of their lean bundles are elements of fitness, while two are related to specific goals related to quality and delivery speed. We propose that HRM and TPM are general practices related to organizational agility, strength and stamina.

The foundation for this line of thinking was laid by early work on the infrastructure for TQM (Rehder, 1989, Dean and Snell, 1991 and Snell and Dean, 1992). Building on this notion, Flynn et al. (1995) examined a set of common practices that formed a foundation for implementation of both JIT-specific and TQM-specific practices. Similarly,Rosenzweig and Roth (2004) differentiated between unique practices and interdependent practices. They found that changing one unique practice impacted the others, with the magnitude of the change varying with the degree of interdependence between them. Thus, we propose that HRM and TPM bundles are part of a firm's general fitness, laying the foundation for the more specific capabilities.

However, HRM and TPM practices, in isolation, won't necessarily provide a solid foundation for implementing other lean practices. Thus, we include two additional bundles of general practices in fitness: manufacturing strategy and supply chain relationships. Without a coherent manufacturing strategy, a firm doesn't have a roadmap to follow or a compass to point its activities in the right direction (Skinner, 1969, Hayes et al., 1988, Ahire and Dreyfus, 2000 and Swink et al., 2005). For example, Ericsson's manufacturing strategy was unable to recognize the severity of the implications of the Philips factory fire. A firm's manufacturing strategy should be aligned with its business strategy (Hayes et al., 1988, Flynn et al., 1995 and Swink et al., 2005) and shared with suppliers, in order to work with them to realize its goals.

Furthermore, Shah and Ward (2007) acknowledge that their four bundles (Shah and Ward, 2003) account for only internally related lean practices and suggest the need for a model of lean that also includes supply chain related practices. As Lewis et al. (2010)argue, many important strategic resources are owned by suppliers. External resources can create an advantage that a firm can build upon by investing in bounded resources, such as skills in specific intra-organizational practices (Lewis et al., 2010). This line of thinking is related to absorptive capacity, which is defined as skill in identifying, assimilating and using new external knowledge (Cohen and Levinthal, 1990 and Jabar et al., 2011), to create a unique organizational competence (Zahra and George, 2002), providing a means to master a new technology or method (Azadegan, 2011). Supplier relationships give a firm access to external resources and capabilities, providing a foundation for absorbing further external knowledge into its internal structure (Morash and Clinton, 1997).

Thus, we define fitness as including HRM practices, TPM practices, manufacturing strategy practices and supplier relationship practices. Fig. 2 provides a summary of the proposed relationship between the sand cone model of cumulative performance and the sand cone of practices. The sand cone of practices is at the right side. At its base is fitness, comprised of practices designed to support general strength, agility and stamina, including bundles of practices related to human resource management, total preventive maintenance, manufacturing strategy and supplier relationships. A firm can pursue alternative goals by building on this foundation. A firm whose goals are based on simultaneous competitive advantages would build the TQM bundle of practices on its fitness foundation, then the JIT bundle. As the TQM practice bundle is developed, the fitness foundation expands, as with the sand cone model of performance. Similarly, as the JIT bundle of practices is honed, the TQM and fitness foundations will continue to expand. There may be additional layers of practices that could potentially be built upon the JIT bundle, as indicated by the box with the question mark. The sand cone of performance is shown at the left side of Fig. 2. In subsequent sections of this paper, we will propose that both TQM and JIT bundles of practices are directly related to quality performance and that the JIT bundle is also directly related to delivery performance. Through quality and delivery performance, the TQM and JIT bundles are proposed to be indirectly related to flexibility performance and cost performance.

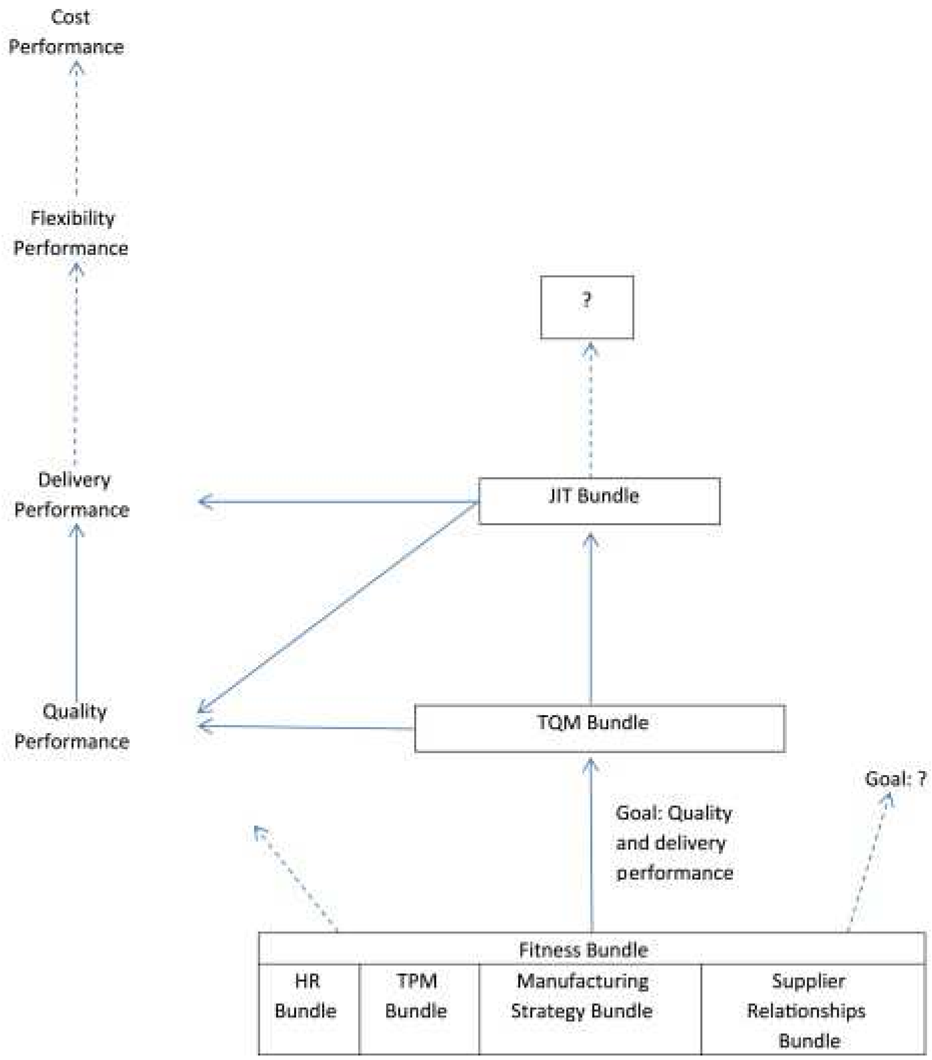

Fig. 2. Conceptual framework: relationship between lean bundles and sand cone.

3. Hypotheses

In developing our hypotheses, we begin with those related to the sand cone of cumulative performance, providing a brief rationale for its sequential accumulation, which has already been established. We then move to developing the base for a sand cone of lean practices, describing the role played by fitness and the TQM and JIT bundles of practices.

3.1. Sand cone of cumulative performance

Quality performance is the base of the sequence described by the sand cone model of performance (Ferdows and De Meyer, 1990 and Flynn and Flynn, 2004). It is recognized as the driver of delivery, flexibility and cost performance (Schmenner and Swink, 1998), because it requires a high degree of control over the process (Roth, 1996a and Roth, 1996b). It provides the foundation for improvements in delivery performance, as follows. As process variance is reduced, cycle times are shortened, allowing speedy throughput, schedule attainment and faster response to market demands (Flynn and Flynn, 2005). If quality performance is high, the resulting reduction in rework will support reduced lead time variance (Wacker, 1996 and Flynn and Flynn, 2004). In order for materials to flow smoothly, it is critical that process variability is minimized, causing process outcomes to be more certain (Schmenner, 2012) and allowing more reliable production scheduling (Rosenzweig and Roth, 2004).

H_1: Quality performance is the base of the sand cone model.
H_{1a}: Quality performance is associated with improvements in delivery performance.

Improved delivery performance forms the foundation for flexibility performance (Ferdows and De Meyer, 1990), in two ways. First, because the time required to respond to variations in customer demand decreases as delivery performance improves, it facilitates making process adjustments to correspond to changing demand requirements (Größler and Grübner, 2006). Second, strong delivery performance is based upon close relationships between a firm and its suppliers, leading to suppliers' potential willingness to absorb demand fluctuations or provide slack capacity (Rosenzweig and Roth, 2004), if necessary. By starting with delivery performance, then building on its reduction of response time and close relationship with suppliers, flexibility performance is improved.

H_{1b}: Delivery performance is associated with improvements in flexibility performance.

Flexibility performance allows changing production volume and mix to directly align with varying customer demand, rather than using finished goods inventory as a buffer to accommodate it (Jack and Raturi, 2002). Accommodating demand variability through flexibility performance involves a much lower time and cost penalty (Swink et al., 2005) than holding inventory buffers (Avella et al., 2011) or other forms of slack resources (Galbraith, 1974). Thus, flexibility performance is directly related to cost performance (Rosenzweig and Roth, 2004). Cost is reduced through flexibility, which aligns production with demand without the use of inventory buffers (Adler et al., 1999).

H_{1c}: Flexibility performance is associated with improvements in cost performance.

3.2. Drivers of cumulative performance

We have argued that fitness provides the foundation for TQM and JIT bundles by contributing to a firm's agility, strength and stamina, which provide the base for the more technical and specific goal oriented practices associated with TQM and JIT. TPM practices facilitate TQM because they reduce process variability, while facilitating JIT by the increase in plant capacity associated with less equipment downtime for unanticipated maintenance (McKone et al., 2001 and Cua et al., 2001). Furlan et al. (2011) described HRM practices as part of the social components of lean, which act as an antecedent to JIT and TQM, creating an environment conducive to the development of more technical practices. Supplier relationships are critical in minimizing the negative impact of unanticipated supply chain disruptions.

H_{2a}: Fitness is an antecedent of TQM.
H_{2b}: Fitness is an antecedent of JIT.

TQM provides tools and approaches for solving quality problems, which decreases process variability through reducing scrap and rework. The primary outcome of TQM is a product without defects (Flynn et al., 1995). It is well established in the literature (Flynn et al., 1995, Cua et al., 2001, Shah and Ward, 2003 and Prajogo and Sohal, 2006) that:

H_{3a}: TQM is directly associated with quality performance.

We propose that TQM is indirectly related to delivery, flexibility and cost performance, supporting the sand cone sequence. TQM has an indirect effect on delivery performance through the reduction of cycle stock, safety stock and rework time. As quality performance improves, there is a decreased need for cycle and safety stocks (Flynn et al., 1995). Producing items for cycle or safety stock or to replace scrapped items consumes time that could otherwise be used for producing items that could be sold to customers. Involving suppliers in quality programs improves raw material quality conformance, thus reducing the time dedicated to quality inspections (Romano, 2002) and rework. TQM has an indirect effect on flexibility, as the production of high quality items with reduced lead times permits development of a process that is better synchronized with demand (Flynn et al., 1995). In turn, TQM is indirectly related to cost performance because there is less of a need for inventories to protect the production system against external variance (Sim and Curatola, 1999) and less invested in scrap and rework. Thus,

H_{3b}: TQM is indirectly associated with delivery, flexibility and cost performance through quality performance, in accordance with the sand cone model sequence.

Through JIT practices, a plant is able to produce the right quantity of products at the right time, thus improving delivery performance. It is well known that JIT is associated with improved delivery performance (Shah and Ward, 2003, Shah and Ward, 2007, Matsui, 2007, Mackelprang and Nair, 2010, Furlan et al., 2011 and Danese et al., 2012), thus,

H_{4a}: JIT is directly associated with improved delivery performance.

JIT is also directly related to quality performance (Flynn et al., 1995) in several ways, thus, contributing to expanding the base of the sand cone of cumulative performance. First, JIT's inventory reduction exposes process problems, through the well-known rocks and river effect (Jacobs and Chase, 2010). Thus, JIT and TQM work hand-in-hand, as JIT exposes problems that are solved through TQM (Flynn et al., 1995). Second, JIT's use of small lot sizes reduces the number of potentially defective items, in the event that there is a quality problem, improving quality performance. Third, JIT's small lot sizes reduce the magnitude of potential handling damage. Thus, it can be argued that:

H_{4b}: JIT is directly associated with quality performance.

JIT is indirectly related to flexibility and cost performance. It is indirectly related to flexibility through its reduction of lot sizes, which facilitates reducing setup times, using small amounts of surge capacity to meet unexpected demand. Through these improvements, flexibility performance improves (Flynn et al., 1995), as small lot sizes make the process more flexible. In addition, for JIT to function effectively, it is important to maintain a close relationship with suppliers, in order synchronize deliveries for meeting customer demand. Synchronized, more frequent deliveries improve delivery performance, as well as flexibility, since the inbound lot size is reduced (Sim and Curatola, 1999). As delivery and flexibility performance are improved, costs are reduced due to the associated reductions in WIP and finished goods inventories (Flynn et al., 1995 and Sim and Curatola, 1999). The opportunity cost of holding large amounts of finished goods to accommodate demand variability is reduced, and funds that could have been invested in finished goods inventory are available for investment elsewhere. Thus, flexibility is improved and inventories are reduced as the result of better quality and delivery performance (Sim and Curatola, 1999 and Fullerton et al., 2003).

H4c: JIT is indirectly associated with flexibility and cost performance through quality and delivery performance, in accordance with the sand cone model sequence.

Fig. 3 summarizes the theoretical framework for this set of hypotheses.

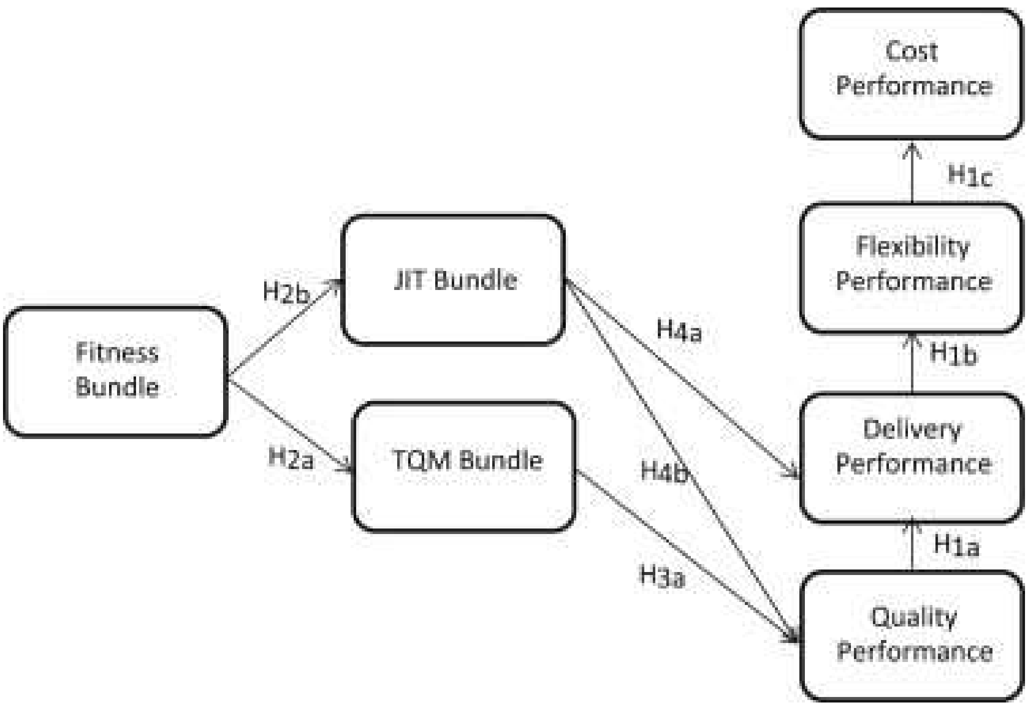

Fig. 3. Theoretical framework.

4. Methodology

4.1. Sample

This study uses data from the third round of the high performance manufacturing (HPM) project data set, collected by an international team of researchers, which was completed in 2010 (Huo et al., 2014, Zhao et al., 2013 and Konecny and Thun, 2011). Participating plants operate in the machinery, electronics and transportation components sectors in ten countries: Finland, US, Japan, Germany, Sweden, South Korea, Italy, Austria, Spain and China. These countries were selected because they contain a mix of high performing and traditional plants, while providing diversity of national cultural and economic characteristics. The sample was stratified, with approximately equal representation across sectors, countries and reputation (high performing versus traditional). Plants were randomly selected from a master list of manufacturing plants in each of the countries based on local sources (e.g., Dun's Industrial Guide, the JETRO database, etc.). Each represented a different parent corporation and had at least 100 employees. Plant managers assigned a plant research coordinator to serve as the liaison with the project team, responsible for distributing the questionnaires to the appropriate respondents and collecting the completed questionnaires, each in a sealed envelope. The research coordinator also assisted the research team when further information was needed about unclear or missing responses. Responses from 317 plants were returned, for a response rate of 65%. Table 2 summarizes the sample characteristics.

Table 2. Respondents by country and industry.

	Industry			
Country	**Electronics**	**Machinery**	**Transportation components**	**Total**
Germany	9	13	19	**41**
Austria	10	7	4	**21**
China	21	16	14	**51**
South Korea	10	10	11	**31**
Spain	9	9	10	**28**
USA	9	11	9	**29**
Finland	14	6	10	**30**
Italy	10	10	7	**27**
Japan	10	12	13	**35**
Sweden	7	19	7	**24**
Total	**109**	**104**	**104**	**317**

Although the set of hypotheses this study intends to test regards lasting improvements over time, we use cross-sectional data, in line with Schroeder et al. (2011), who contended that data collected at any one point in time can be used to test the lasting and cumulative effects of the sand cone, if mediation or sequential effects are checked, rather than simply correlations or regression results. Therefore, to follow this recommendation, which is widely accepted in the OM field, we employ indirect effects and alternative sequences analyses which are not limited to simple correlations or regressions.

4.2. Questionnaires

The questionnaires included a mix of objective and perceptual measures. Each plant received a battery of 23 questionnaires, each targeted at a specific set of respondents, in order to minimize the potential for common method bias. For example, questions about performance were on the plant manager questionnaire, while questions about employee suggestions were on the direct labor and human resource manager questionnaires.Table 3 contains a summary of the distribution of questionnaires within each plant.

Table 3.Distribution of questionnaires.

Respondent	**Number of respondents per plant**
Plant accounting manager	1
Direct labor	10
Human resources manager	1
Information systems manager	1
Production control manager	1
Inventory manager	1
Member of product development team	1
Process engineer	1
Plant manager	1
Quality manager	1
Supervisor	3
Plant superintendent	1
Total respondents per plant	**23**

4.3. Measurement scales

The HPM items were originally developed in English and translated into the local language by a member of the local research team. They were then back-translated into English by a different local team member, to assure accuracy in translation. Theappendix lists the items contained in each scale, which were a subset of the HPM survey items. The first-order constructs represent practices, which covered the most salient aspects of each scale, supporting content validity (Nunnally, 1978). The fitness, JIT and TQM bundles were conceptualized as second-order factors and were measured through the first-order factors, each corresponding to a specific practice and measured using a multi-item scale. Among the perceptual items, some were reverse coded, to further reduce the possibility of common methods variance. The items in the scales were operationalized as Likert-scale items, with values ranging from 1 (“strongly disagree”) to 7 (“strongly agree”).

To measure operational performance, we employed four first-order constructs, following Ferdows and De Meyer’s (1990) dimensions. Each plant’s manager provided his or her opinion about the plant’s performance, compared with its competitors, on a 5-point Likert scale, ranging from 1 (poor, at the low end of the industry) to 5 (superior to industry competitors). Performance measures were administered to a single respondent because the plant manager should be the most knowledgeable about a plant’s performance on multiple dimensions, relative to its competitors. To reduce potential bias due to using a single respondent for performance, we ensured that the perceptual performance measures were correlated with independent, objective data gathered from different respondents, who were knowledgeable about individual performance measures, using triangulation (see Table 4). Quality and cost performance were each measured using a single item, using the same items as Bozarth et al. (2009). Single-item perceptual measures are acceptable when the object of the construct is concrete, uniformly imagined (Bozarth et al., 2009) and when it is sufficiently narrow and unambiguous to the respondent (Wanous et al., 1997); thus, a number of studies using single-item perceptual measures can be found in the operations management literature (Koufteros et al., 1998,Sawhney and Piper, 2002, Bergkvist and Rossiter, 2007, Bozarth et al., 2009, Gimenez et al., 2012 and Sawhney, 2013). Delivery and flexibility performance were each measured as two-item measures, using the measures validated by Liu et al. (2009) andMcKone-Sweet and Lee (2009).

Table 4.Triangulation between perceptual and objective performance measures.

Performance dimension	Perceptual measure	Objective measure	Pearson correlation coefficient
Cost performance	Unit cost of manufacturing	Manufacturing costs ($000)	.16*
Quality performance	Conformance to product specifications	Percent of defective products returned	.10*
Delivery performance	On time delivery performance	Percent of orders shipped on time	.34**
	Fast delivery	Average lead time, from receipt of an order until it is shipped (days)	.27**
Flexibility performance	Flexibility to change product mix	Total cycle time, from receipt of raw materials until the product is received by customer (days)	.12*
	Flexibility to change volume	Total cycle time, from receipt of raw materials until the product is received by customer (days)	.11*

Note: *p<.05, ** p<.01.

The use of perceptual, rather than objective, measures for operational performance facilitated controlling for potential industry effects, since the perceptual measures compare the performance of a plant with its competitors in the same sector, while objective measures would be more difficult to compare across different sectors (Martínez-Costa et al., 2009 and Danese, 2013). As done by Danese and Kalchschmidt (2011), to control for the risk of perceptual bias, we used triangulation to verify the existence of a statistically significant correlation between each perceptual measure and corresponding objective measures, as reported in Table 4.

4.4. Validity

4.4.1. Content validity

The scales in the HPM project were developed based on existing literature and previously validated measures, when available. Table 5 lists practices described by previous lean research and the bundles/constructs formed by these practices. Flynn et al. (1995) studied JIT and TQM practices and their common infrastructure; similarly, Cua et al. (2001) analyzed JIT, TQM and TPM as specific practices, as well as their infrastructure. Mackelprang and Nair (2010) did not distinguish between different groups of practices, whereas other studies (Sakakibara et al., 1997, Ahmad et al., 2003, Shah and Ward, 2003, Swink et al., 2005 and Furlan et al., 2011) classified lean practices into groups related to HRM, TPM, strategy integration, or supplier relationship management, as well as JIT and TQM.

Table 5. Classification of lean manufacturing practices in the literature.

Bundle	Practice	Mackelprang and Nair(2010)	Flynn et al.(1995)	Swink et al.(2005)	Cua et al.(2001)	Ahmad et al. (2003)	Fu al
Fitness	TPM	JIT			TPM		
	Cleanliness and organization		Infrastructure		TPM		TC
	Small group problem solving		Infrastructure	HRM			HI
	Multi-functional employees		Infrastructure	HRM	Infrastructure	HRM	
	Employee suggestions		Infrastructure		Infrastructure		HI
	Continuous improvement			TQM			HI
	Supplier partnership		Infrastructure	Supplier relationship management		TQM	
	Manufacturing-business strategy linkage		Infrastructure	Strategy integration	Infrastructure		
JIT	Daily schedule adherence	JIT	JIT		JIT	JIT	JI
	Flow-oriented layout	JIT		JIT	JIT	JIT	JI
	JIT links with suppliers	JIT			JIT	JIT	JI
	Kanban	JIT	JIT	JIT	JIT	JIT	JI
	Setup time reduction	JIT	JIT		JIT	JIT	JI
TQM	Statistical process control		TQM	TQM	TQM	TQM	TC
	Process feedback			TQM	Infrastructure	TQM	
	Top management leadership for quality		Infrastructure		Infrastructure		
	Customer involvement		TQM		TQM	TQM	
	Supplier quality involvement				TQM	TQM	

Table 5 reveals that there is a wide consensus on what comprises JIT practices. The five practices that we used to operationalize TQM were classified as TQM practices by a number of previous studies. Some authors define top-management leadership and process feedback as infrastructural practices, rather than as TQM. However, since in this study, these practices are measured in terms of their relationship to quality management, we included them in TQM. Finally, the practices that were explicitly classified as commonly used with both JIT and TQM in studies of Flynn et al. (1999) and Cua et al. (2001) were included as part of our fitness bundle.

The content validity of each measure was also checked through discussions with experts and managers. The scales were pilot tested in each of the countries, in order to ensure that the translation was correct and understandable and that the content of the items was clear. Although the format of the pilot testing varied by country, it typically consisted of administering the questionnaire to a focus group in a plant, followed by an informal roundtable discussion about the ease of completion and understandability of the items.

4.4.2. Unidimensionality

Confirmatory factor analysis (CFA) requires that data do not violate the normality assumptions underlying SEM. We verified that all items exhibited univariate normality by examining their skewness, kurtosis, and normal probability plots and checked for multivariate normality through the residuals test. After the normality assumption was verified, an iterative modification process, based on CFA, permitted simultaneous refinement of the measures and assessment of the unidimensionality of the first- and second-order constructs. We ran a single-factor CFA for each measure, then iteratively improved the parameters and fit statistics, using LISREL 8.80. If the recommended parameters were not achieved, we eliminated one item at time until the recommended model parameters were satisfied (Joreskog and Sorbom, 1989). If a construct had fewer than four items, the iterative modification process was conducted on a two-construct model, where the second construct was used as a common basis of reference, in order to have sufficient degrees of freedom to compute fit statistics (Li et al., 2005). Table 6reports composite reliability for the measurement model, while the factor loadings are contained in the appendix.

Table 6. Composite reliability.

Bundle	Construct	Composite α	χ2	d.f.	RMSEA	CFI
Fitness	Employee suggestions	.871	1077	621	.0494	.979
	Multi-functional employees	.854				
	Small group problem solving	.875				
	Manufacturing-business strategy linkage	.806				
	Cleanliness and organization	.886				
	Continuous improvement	.809				
	Supplier partnership	.757				
	Total preventive maintenance	.778				
JIT	Daily schedule adherence	.843	300.21	165	.0508	.982
	Equipment layout	.843				
	JIT delivery by suppliers	.750				
	Kanban	.815				
	Setup time reduction	.767				
TQM	Customer involvement	.794	391.46	204	.0536	.979
	Feedback	.804				
	Process control	.880				
	Top management leadership for quality	.848				
	Supplier quality involvement	.823				

4.4.3. Convergent validity

Convergent validity is demonstrated when all factor loadings on the first-order latent construct are statistically significant and greater than 0.50; similarly, convergent validity for the second-order constructs is verified when all factor loadings for the first-order latent constructs on their second-order latent construct are statistically significant and greater than 0.50 (Anderson and Gerbing, 1988). Convergent validity was demonstrated for this model because the factor loadings for all first- and second-order constructs were significant at the 0.01 level and greater than 0.50.

4.4.4. Discriminant validity

Discriminant validity for the first and second-order factors was assessed using the delta Chi-square test (Bagozzi et al., 1991). For each pair of first-order factor constructs, two nested models were compared. The first model calculated the unconstrained correlation between each pair of constructs, while the correlation was fixed to 1 in the second model. A significant Chi-square difference indicates that the two constructs are distinct. In our tests, all the Chi-square differences were statistically significant at the 0.01 level, with the lower delta Chi-square of 43.12, thus demonstrating the discriminant validity of the constructs. The same procedure was followed for the second-order constructs. The results demonstrated discriminant validity, as the lower delta Chi-square was 172.57, demonstrating that all the scales were distinct from each other (Bagozzi et al., 1991).

4.4.5. Reliability

We assessed the reliability of each first-order construct using composite reliability. The composite reliability values, reported in Table 6, were all greater than 0.70, thus indicating that each first-order construct is consistent and free from random errors.

5. Analysis

The analysis was conducted at the plant level. Individual informants' responses to each question were aggregated at the plant level by taking the mean of the within-plant responses. Consistent with other studies (Bozarth et al., 2009, Mishra and Shah, 2009 and Bortolotti et al., 2013), we controlled for industry and country effects by standardizing the individual items making up the measures. Although we recognize that country and industry differences may be related to differences in the practices implemented and performance achieved, our intent was to test whether our model was valid at the plant level.

5.1. Building the structural model

We assessed the model fit for each practice bundle (the second-order factors) by verifying overall model fit and the absolute (RMSEA), incremental (CFI) and parsimonious (χ^2) fit indices. Then, we checked that fit indices were above the recommended cutoff points, indicating that the measurement model is acceptable. To test the hypotheses, the items comprising each first-order factor were parceled, in order to reduce the complexity of the model and meet the minimum sample size required for structural equation modeling (SEM) analysis. For each practice, we computed a single indicator (the mean of the items), permitting development of a simpler model that is not over- specified (Cua et al., 2001 and Sila, 2007). We employed MacCallum et al. (1996)to verify that our sample size was consistent with the minimum sample size required for adequate statistical power.

5.2. Alternative models

To test whether the sand cone model sequence of cumulative performance was related to the bundles of lean practices and whether it could be considered superior to other potential sequences, we also tested alternative models derived from the literature (Amoako-Gyampah and Meredith, 2007; Corbett and Whybark, 2001, Hall and Nakane, 1990 and Nakane, 1986). All the tested models include quality as the base. The statistically supported models were compared using the AIC and CAIC indices, to determine which best represented the data.

6. Results

6.1. Hypothesized structural model

The CFA indicates that the measurement model is acceptable. Fig. 4 reports the results for the SEM model of the theoretical framework. The fit indices indicate that the SEM model fits the data well (χ^2=705.51; d.f.=246; χ^2/d.f.=2.86<3; RMSEA=0.076<0.08; CFI=.953>.95). The fitness bundle was significantly associated with the JIT and TQM bundles, supporting H_{1a} and H_{1b}. These results also support H_{2a}, H_{2b} and H_{2c}, since quality performance was directly related to delivery performance, delivery performance was directly related to flexibility performance, and flexibility performance was directly related to cost performance. In addition, TQM was directly associated with quality performance, while JIT was directly associated with both quality and delivery performance, supporting H_{3a}, H_{4a}, H_{4b}.

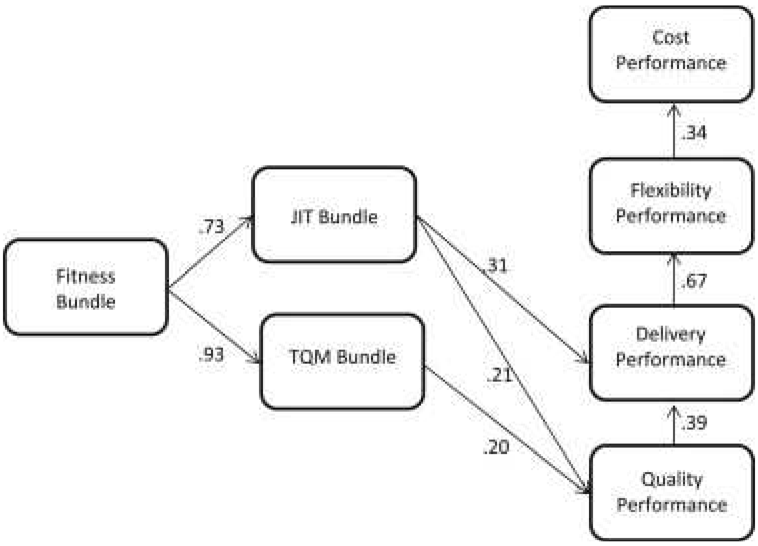

Fig. 4. SEM results.

Table 7 reports the indirect effects of the JIT and TQM bundles on each of the dimensions of cumulative performance. TQM was indirectly associated with delivery, flexibility and cost performance, and JIT was indirectly associated with flexibility and cost performance, supporting H3b, and H4c. Table 7 also reports the other indirect effects.

Table 7. Direct and indirect effects.

	JIT	TQM	Quality performance	Delivery performance	Cost performance	Flexibility performance
Direct effects						
Fitness	.7284[a](9.397)	.9330 (11.175)				
JIT			.214 (2.271)	.280 (4.32)		
TQM			.197 (2.124)			
Quality performance				.387 (6.25)		
Delivery performance					.320 (4.74)	
Cost performance						.33 (4.06)
Flexibility performance						
Indirect effects						
Fitness			.57 (5.70)	.52 (6.30)	.28 (5.1)	.14 (3.80)
JIT				.12 (2.20)	.30 (4.50)	.15 (3.50)
TQM				.12 (2.10)	.10 (2.00)	.09 (1.97)
Quality performance					.19 (4.90)	.09 (3.70)
Delivery perfomance						.26 (4.50)

Note: a Standardized coefficient, (t-value).

6.2. Alternative models

All sequences of cumulative performance in the alternative models were also statistically supported, as shown in Table 8. Since the sand cone model had lower model AIC and CAIC values, we concluded that the sand cone model better represented the sequence of cumulative performance than any of the alternative models.

Table 8. Fit Indices for alternative models.

Sequence*	χ^2	χ^2/d.f.	RMSEA	CFI	AIC	CAIC
Q–D–F–C	705.51	2.86	0.076	0.953	813.51	1070.49
Q–D–C–F	754.92	3.07	0.081	0.944	865.13	1122.11
Q–C–D–F	717.92	2.92	0.080	0.951	842.15	1098.54
Q–C–F–D	742.64	3.02	0.081	0.947	956.10	1113.14
Q–F–C–D	774.95	3.15	0.082	0.942	877.03	1134.93
Q–F–C–D	725.37	2.95	0.080	0.949	845.39	1101.44

Note: Q: quality; D: delivery; F: flexibility; C: cost.

7. Discussion

This research establishes a link between the lean literature and the literature on cumulative performance, providing an alternative and complementary view for interpreting how sequencing bundles of lean practices is related to cumulatively improving performance. In particular, it operationalizes fitness (Ferdows and Thurnheer, 2011) and proposes it as an explanation for the inconsistent results about lean practices and the sand cone model of cumulative performance in the prior literature. It makes a number of important contributions to the operations strategy and lean literature, as well as to management practice.

7.1. Sand cone of practices

This research expands the line of prior research that explored the notion of a sand cone of practices to support cumulative performance. We proposed that fitness establishes the foundation for layering the development of bundles of more specific, targeted practices, based on the work of Ferdows and Thurnheer (2011) and Shah and Ward, 2003 and Shah and Ward, 2007. Our tests of H_{2a} and H_{2b} were strongly supported, indicating that there is more to achieving cumulative performance than simply developing bundles of specific practices in a particular sequence. Rather, it is the firms that have a strong foundation of integrated, general practices that benefit the most from a sand cone of practices. Thus, we found that fitness provides a critical foundation for a sand cone of practices. Like the sand cone of performance, the base of fitness should continue to expand, as bundles of more specific practices are layered upon it. These findings are related to the literature on capabilities (Lee and Kelley, 2008, Leonard-Barton, 1992,Rothaermel and Hess, 2007, Schreyogg and Kleisch-Eberl, 2007, Teece et al., 1997 and Wu et al., 2010), which describes how the development of capabilities is idiosyncratic and path dependent, developed as a firm solves its unique problems. Thus, as a firm adapts TQM and JIT bundles of practices to its own context, it further develops its capabilities associated with fitness, expanding this foundation.

A second theoretical contribution concerns the role of supplier relationships. In line with the extended resource based view (Lewis et al., 2010) and the absorptive capacity literature (Zahra and George, 2002 and Cohen and Levinthal, 1990), our findings confirm that the identification, assimilation and use of external resources can help firms in mastering lean cumulatively, thereby improving performance. This research provides additional insight on how this takes place. On the one hand, the creation of a general collaborative attitude towards suppliers is central to fitness, as it strengthens the foundation on which firms successively build specific JIT and TQM skills. On the other hand, after these initial favorable conditions have been created, suppliers can effectively support specific JIT and TQM practices by synchronizing their deliveries according to the JIT logic (e.g. small and frequent lots, kanban containers, milk runs) and cooperating in quality improvement programs. Thus, tight supplier relationships provide a firm with access to resources beyond its immediate boundaries. Through its ties with its supply chain partners and their partners, it gains important insights that further develop the foundation for specific practice bundles.

7.2. Support for the sand cone model

Our findings support the sand cone model of cumulative performance. Although this has not always been the case in the prior research, we did not assume that the sand cone model was universal. This is consistent with the statment of Ferdows and De Meyer (1990) that the sand cone model is an approach that is used only by the best firms, those that are able to counteract what appear to be tradeoffs. However subsequent researchers have often viewed it as though every firm should follow the sand cone sequence of cumulative performance. By introducing the concept of fitness, we limited the domain of the sand cone model to the firms with a strong foundation of general, integrated practices and capabilities. Our tests of H_{1a} through H_{1c} support the sand cone model sequence of Ferdows and De Meyer (1990), while our tests of H_2 through H_4support the relationship between the sand cone of practices and the sand cone model of cumulative performance.

7.3. Alternative sequences of cumulative performance

Although the sand cone model is well known and has been widely cited, some authors have suggested alternative sequences of cumulative capabilities. Schroeder et al. (2011)demonstrated that different plants can follow distinct progressions of outcome objectives. They argued that the sand cone only represents one possible sequence of cumulative capabilities in particular contexts. However, the data set of Schroeder et al. (2011)included a wide variety of plants, not just high performing plants; thus, it is not surprising that a sand cone sequence of practices was ineffective for some of them. Our research contributes to the sand cone model literature by testing alternative sequences of cumulative performance. Used in conjunction with our proposed sand cone of practices, with fitness at the base, all sequences that began with quality were found to be valid. However, the sand cone sequence was the most strongly supported, enhancing the validity of this model. Thus, we did not seek to test whether the sand cone model is universal; we don’t believe that it is or was ever meant to be. Rather, we found that, for firms that nurture cumulative performance through a sequence of lean practices that starts with fitness, the sand cone performance sequence was the strongest.

7.4. Contributions to the lean literature

This research contributes to the lean literature through its closer examination of Shah and Ward, 2003 and Shah and Ward, 2007 bundles of lean practices. Their research was important, carefully articulating the dimensions of lean and empirically determining which were related. Our research builds upon this by separating lean bundles of Shah and Ward (2003) into two groups: those that are related to general organizational fitness and those that are more goal focused. Further, H_{2a} and H_{2b} show that the TQM and JIT bundles build on the more general fitness bundles. This is consistent with the prior literature on the infrastructure for TQM (Dean and Snell, 1991, Snell and Dean, 1992,Rehder, 1989 and Flynn et al., 1995). As with an athlete, prowess in both bundles is important, but they function in different ways; organizational fitness builds speed, agility and strength (Ferdows and Thurnheer, 2011), while the TQM and JIT bundles build capabilities that support simultaneous competitive performance.

By testing the sand cone model and the direct and indirect effects of the TQM and JIT bundles of practices on each dimension of performance, our research leads to important recommendations about the sequence of practices firms should follow when implementing lean. Our results demonstrate that the TQM bundle is directly related to quality performance, thus, it is the starting point for the successive improvement of the other dimensions of performance. The JIT bundle directly improves quality and delivery performance, which represent the second, additional step in the improvement sequence suggested by the model of Ferdows and De Meyer (1990). We found that both the TQM and JIT bundles are indirectly related to the higher performance levels through their relationship to quality and delivery performance, strongly supporting the sand cone sequence of cumulative performance. In this way, our research can help managers overcome the tradeoff faced when considering multiple dimensions of performance, since they don't have to concentrate on one dimension at the expense of another. In a larger sense, this research contributes to the debate about causal relationships between lean practices, theorizing about and testing the existence of antecedents that facilitate the implementation of bundles of lean practices. Much of the prior research (Cua et al., 2001, McKone et al., 2001 and Furlan et al., 2011) considered only a limited set of lean practices, thus decreasing the generalizability of its findings. This research overcomes this limitation since it does not focus on a specific practice, such as HRM or TPM, as an antecedent, but instead combines them, along with manufacturing strategy and supplier relationships into a single bundle, called fitness. Our results (H_{2a} and H_{2b}) support the idea that fitness is an antecedent to JIT and TQM.

7.5. Managerial implications

Knowledge about sequences of performance improvement can help managers develop their operations strategy. In particular, fitness is an important new construct with substantial practical implications. This research fleshed out Ferdows and Thurnheer's (2011) fitness construct and demonstrated how it functions as the foundation for bundles of lean practices and, ultimately, cumulative performance. Managers can strive to develop and improve organizational fitness by activities such as educating and training employees, fostering an organizational culture based on continuous improvement (Lee et al., 2013), communicating and sharing their manufacturing strategy with other functional areas, and creating a foundation for fruitful collaboration with suppliers, in order to decrease the risk of cultural resistance to change, as well as improving the production environment. Subsequently, they should direct their efforts towards TQM, in order to improve quality performance and indirectly contribute to other types of performance. Once product quality has reached a sufficient level, JIT practices can be developed, to further foster quality performance and improve delivery performance. Once these lean bundles have been sufficiently introduced, following the implementation sequence suggested above, it is possible to achieve excellence on multiple dimensions of performance by continuing to simultaneously leverage these lean practices.

Lean implementation is characterized by a cumulative pattern. When implementing bundles of lean practices, managers should consider the development of fitness as a priority in preparing for the implementation of more technical lean practices, in order to facilitate their implementation at a more advanced stage. The TQM bundle is the second layer, directly connected with the base of the sand cone cumulative performance model (Ferdows and De Meyer, 1990). The JIT bundle is the final layer of the sand cone of practices that we investigated, impacting the second layer of the cumulative performance sand cone. Our findings revealed that the sand cone of practices is indirectly connected with the third and fourth layers of the cumulative performance sand cone.

7.6. Limitations and opportunities for future research

It is important to reflect on potential limitations and how they can be translated into opportunities for future research. In considering a sand cone of practices, our research focused only on strategic goals related to quality and delivery, thus, it considered only the effect of lean practice bundles. Although we found that they were related to the entire sand cone of performance, as expected, this research did not consider what sorts of practices might be layered on top of the lean practices. Our model suggests that lean bundles are related to the base of the sand cone model, by directly improving quality and delivery performance, with flexibility and cost performance only affected indirectly. Other practices may increase the height of the sand cone by reinforcing performance at both its base and top. Determining their composition is an important challenge for future research. For instance, the use of automated flexible lines may impact flexibility and, in turn, cost performance. We expect that, as with the sand cone of cumulative performance, the foundation provided by lean bundles will continue to expand as other practices more specifically targeted at flexibility and cost performance are layered on top of them. It is not clear how these practices interact with lean and whether fitness will facilitate their implementation.

The concept of fitness (Ferdows and Thurnheer, 2011) is an intriguing and potentially very important construct. In order to be consistent with Shah and Ward (2003), we focused on their lean bundles that were more general in nature, as we operationalized fitness, supplementing them with manufacturing strategy and supplier relationship practices. However, it is likely that there are other bundles of practices that also contribute to an organization's general fitness. We believe that the concept of fitness is in its infancy and is a fruitful area for future research. A good starting point may be case studies of companies that were agile in the face of a supply chain disruption or natural disaster, such as those described by Sheffi and Rice (2005), as they can provide rich information about the role of seemingly unrelated capabilities. Careful comparison of such cases may reveal other important components of fitness.

Although widely used in the OM literature (Schroeder et al., 2011), the cross-sectional nature of the analysis could potentially limit our findings on the causal relationships among variables. Ferdows and De Meyer's (1990) original development of the sand cone model was stated in terms of lasting improvements over time, thus it would be logical to test the sand cone model using longitudinal data. Future research may extend these findings through longitudinal case studies, with the aim of collecting richer information regarding a sand cone of practices and its relationship to cumulative performance.

Finally, an interesting future research topic is related to the role of exogenous and contingent variables that may moderate the relationship between lean bundles and cumulative performance, leading to trade-offs with operational performance. For example, can lean and sustainability practices coexist without affecting the path of cumulative capabilities? The use of environmental sustainability criteria in supplier selection may be inconsistent with lean requirements for JIT deliveries, or the aim of improving social sustainability could be in contrast with lean emphasis on time reduction. What is the role of differences in industry and country? These present exciting opportunities for future research.

Appendix A. Construct measurement

Table A1.

Construct measurement.

Construct	Item	Factor loading
Operational performance [a]		
Please indicate how your plant's performance compares with its global competitors, on each of the following dimensions:		
Cost	Unit cost of manufacturing	
Quality	Quality conformance	
Delivery	On-time delivery performance	
	Fast delivery	
Flexibility	Flexibility to change product mix	
	Flexibility to change volume	
JIT practices [b]		
Daily schedule adherence	We usually meet the production schedule each day	.888
	Our daily schedule is reasonable to complete on time	.649
	We usually complete our daily schedule as planned	.881
	We cannot adhere to our schedule on a daily basis (reverse worded)	.622
Equipment layout	We have laid out the shop floor so that processes and machines are in close proximity to each other	.755
	The layout of our shop floor facilitates low inventories and fast throughput	.819
	Our processes are located close together, so that material handling and part storage are minimized	.777
	We have located our machines to support JIT production flow	.682
JIT delivery by suppliers	Our suppliers deliver to us on a just-in-time basis	.712
	We receive daily shipments from most suppliers	.514
	We can depend upon on-time delivery from our suppliers	.635
	Our suppliers are linked with us by a pull system	.554
	Suppliers frequently deliver materials to us	.626
Kanban	Our suppliers deliver to us in Kanban containers, without the use of separate packaging	.671
	We use a Kanban pull system for production control	.809
	We use Kanban squares, containers or signals for production control	.849
Setup time reduction	We are aggressively working to lower setup times in our plant	.608
	We have converted most of our setup time to external time, while the machine is running	.686
	We have low setup times of equipment in our plant	.709
	Our crews practice setups, in order to reduce the time required	.523

Construct	Item	Factor loading
TQM practices[b]		
Customer involvement	We frequently are in close contact with our customers	.639
	Our customers give us feedback on our quality and delivery performance	.708
	We strive to be highly responsive to our customers' needs	.702
	We regularly survey our customers' needs	.753
Feedback	Charts showing defect rates are posted on the shop floor	.779
	Charts showing schedule compliance are posted on the shop floor	.722
	Charts plotting the frequency of machine breakdowns are posted on the shop floor	.674
	Information on quality performance is readily available to employees	.693
Process control	A large percent of the processes on the shop floor are currently under statistical quality control	.811
	We make extensive use of statistical techniques to reduce variance in processes	.854
	We use charts to determine whether our manufacturing processes are in control	.671
	We monitor our processes using statistical process control	.904
Top management leadership for quality	All major department heads within the plant accept their responsibility for quality	.669
	Plant management provides personal leadership for quality products and quality improvement	.822
	Our top management strongly encourages employee involvement in the production process	.633
	Our plant management creates and communicates a vision focused on quality improvement	.815
	Our plant management is personally involved in quality improvement projects	.702
Supplier quality involvement	We strive to establish long-term relationships with suppliers	.784
	Quality is our number one criterion in selecting suppliers	.548
	We use mostly suppliers that we have certified	.651
	We maintain close communication with suppliers about quality considerations and design changes	.715
	We actively engage suppliers in our quality improvement efforts	.779
Fitness [b]		
Employee suggestions	Management takes all product and process improvement suggestions seriously	.815
	We are encouraged to make suggestions for improving performance at this plant	.816
	Management tells us why our suggestions are implemented or not used	.723

Construct	Item	Factor loading
	Many useful suggestions are implemented at this plant	.819
	My suggestions are never taken seriously around here (reverse worded)	.617
Multi-function employees	Our employees receive training to perform multiple tasks	.788
	Employees at this plant learn how to perform a variety of tasks	.836
	The longer an employee has been at this plant, the more tasks they learn to perform	.829
	Employees are cross-trained at this plant, so that they can fill in for others, if necessary	.644
Small group problem solving	During problem solving sessions, we make an effort to get all team members' opinions and ideas before making a decision	.660
	Our plant forms teams to solve problems	.827
	In the past three years, many problems have been solved through small group sessions	.780
	Problem solving teams have helped improve manufacturing processes at this plant	.830
	Employee teams are encouraged to try to solve their own problems, as much as possible	.629
	We don't use problem solving teams much, in this plant (reverse worded)	.704
Manufacturing-business strategy Linkage	Our business strategy is translated into manufacturing terms	.632
	Potential manufacturing investments are screened for consistency with our business strategy	.724
	At our plant, manufacturing is kept in step with our business strategy	.858
	Manufacturing management is not aware of our business strategy	.595
	Corporate decisions are often made without consideration of the manufacturing strategy	.567
Cleanliness and organization	Our plant emphasizes putting all tools and fixtures in their place	.741
	We take pride in keeping our plant neat and clean	.862
	Our plant is kept clean at all times	.877
	Our plant is disorganized and dirty (reverse worded)	.774
Continuous improvement	We strive to continually improve all aspects of products and processes, rather than taking a static approach	.746
	If we aren't constantly improving and learning, our performance will suffer in the long term	.516
	Continuous improvement makes our performance a moving target, which is difficult for competitors to attack	.733
	We believe that improvement of a process is never complete; there is always room for more incremental improvement	.640
	Our organization is not a static entity, but engages in	.746

Construct	Item	Factor loading
	dynamically changing itself to better serve its customers	
Supplier partnership	We maintain cooperative relationships with our suppliers	.765
	We provide a fair return to our suppliers	.604
	We help our suppliers to improve their quality	.584
	Our key suppliers provide input into our product development projects	.702
Autonomous maintenance	Operators understand the cause and effect of equipment deterioration	.661
	Basic cleaning and lubrication of equipment is done by operators	.654
	Operators inspect and monitor the performance of their own equipment	.756
	Operators are able to detect and treat abnormal operating conditions of their equipment	.666

a Please circle the number that indicates your opinion about how your plant compares to its competitors in your industry, on a global basis (5: superior, 4: better than average, 3:average or equal to the competition, 2: below average, 1: poor or low).

b Please indicate the extent to which you agree/disagree with the following (1: strongly disagree, 2: disagree, 3:slightly disagree, 4:neutral, 5: slightly agree, 6: agree, 7:strongly agree).

References

Adler, P.S., Goldoftas, B., Levine, D.I., 1999. Flexibility versus efficiency? A case study of model changeovers in the Toyota production system. Organ. Sci. 10 (1), 43–68.

Ahire, S.L., Dreyfus, P., 2000. The impact of design management and process management on quality: an empirical investigation. J. Oper. Manage. 18 (5), 549–575.

Ahmad, S., Schroeder, R.G., Sinha, K.K., 2003. The role of infrastructure practices in the effectiveness of JIT practices: implications for plant performance. J. Eng. Technol. Manage. 20 (3), 161–191.

Amoako-Gyampah, K., Meredith, J.R., 2007. Examining cumulative capabilities in a developing economy. Int. J. Oper. Prod. Manage. 27 (9), 928–950.

Anderson, J.C., Gerbing, D.W., 1988. Structural equation modeling in practice: a review and recommended two-step approach. Psychol. Bull. 103 (3), 411–423.

Avella, L., Vazquez-Bustelo, D., Fernandez, E., 2011. Cumulative manufacturing capabilities: an extended model and new empirical evidence. Int. J. Prod. Res. 49 (3), 707–729.

Azadegan, A., 2011. Benefiting from supplier operational innovativeness: the influence of supplier evaluations and absorptive capacity. J. Supply Chain Manage. 47 (2), 49–64.

Bagozzi, R.P., Yi, Y., Phillips, L.W., 1991. Assessing construct validity in organizational research. Admin. Sci. Q. 36 (3), 421–458.

Bergkvist, L., Rossiter, J.R., 2007. The predictive validity of multiple-item versus single-item measures of the same constructs. J. Marketing Res. 44 (2), 175–184.

Bortolotti, T., Danese, P., Romano, P., 2013. Assessing the impact of just-in-time on operational performance at varying degrees of repetitiveness. Int. J. Prod. Res. 51 (4), 1117–1130.

Boyer, K.K., Lewis, M.W., 2002. Competitive priorities: investigating the need for trade-offs in operations strategy. Prod. Oper. Manage. 11 (1), 9–20.

Bozarth, C.C., Warsing, D.P., Flynn, B.B., Flynn, E.J., 2009. The impact of supply chain complexity on manufacturing plant performance. J. Oper. Manage. 27 (1), 8–93.

Chen, I.J., Paulraj, A., 2004. Towards a theory of supply chain management: the constructs and measurements. J. Oper. Manage. 22 (2), 119–150.

Clark, K.B., 1996. Competing through manufacturing and the new manufacturing paradigm: is manufacturing strategy passé? Prod. Oper. Manage. 5 (1), 42–58.

Cohen, W., Levinthal, D., 1990. Absorptive capacity: a new perspective on learning and innovation. Admin. Sci. Q. 35, 128–152.

Corbett, C., Van Wassenhove, L., 1993. Trade-offs? What trade-offs? Competence and competitiveness in manufacturing strategy. Calif. Manage. Rev., 107–122 (Summer).

Corbett, L.M., Whybark, D.C., 2001. Searching for the sandcone in the GMRG data. Int. J. Oper. Prod. Manage. 21 (7), 965–980.

Cua, K.O., McKone, K.E., Schroeder, R.G., 2001. Relationship between implementation of TQM. JIT, and TPM, and manufacturing performance. J. Oper. Manage. 19 (6), 75–694.

Danese, P., 2013. Supplier integration and company performance: a configurational view. Omega 41 (6), 1029–1041.

Danese, P., Kalchschmidt, M., 2011. The role of the forecasting process in improving forecast accuracy and operational performance. Int. J. Prod. Econ. 131 (1), 204–214.

Danese, P., Romano, P., Bortolotti, T., 2012. JIT production, JIT supply and performance: investigating the moderating effects. Ind. Manage. Data Syst. 112 (3), 441–465.

D'Aveni, R., 1994. Hypercompetition. Free Press, New York, NY.

Dean Jr., J.W., Snell, S.A., 1991. Integrated manufacturing and job design: moderating effects of organizational inertia. Acad. Manage. J. 34, 776–804.

Dess, G.G., Davis, P.S., 1984. Porter's generic strategies as determinants of strategic group membership and organizational performance. Acad. Manage. Rev. 27, 467–488.

Ferdows, K., De Meyer, A., 1990. Lasting improvements in manufacturing performance: in search of a new theory. J. Oper. Manage. 9 (2), 168–184.

Ferdows, K., Thurnheer, F., 2011. Building factory fitness. Int. J. Oper. Prod. Manage. 31 (9), 916–934.

Flynn, B.B., Flynn, E.J., 2004. An exploratory study of the nature of cumulative capabilities. J. Oper. Manage. 22 (5), 439–457.

Flynn, B.B., Flynn, E.J., 2005. Synergies between supply chain management and quality management: emerging implications. Int. J. Prod. Res. 43 (16), 421–3436.

Flynn, B.B., Sakakibara, S., Schroeder, R.G., 1995. Relationship between JIT and TQM: practices and performance. Acad. Manage. J. 38 (5), 1325–1360.

Flynn, B.B., Schroeder, R.G., Flynn, E.J., 1999. World class manufacturing: an investigation of Hayes and Wheelwright's foundation. J. Oper. Manage. 17, 249–269.

Fullerton, R.R., McWatters, C.S., Fawson, C., 2003. An examination of the relationship between JIT and financial performance. J. Oper. Manage. 21 (4), 383–404.

Furlan, A., Vinelli, A., Dal Pont, G., 2011. Complementarity and Lean manufacturing bundles: an empirical analysis. Int. J. Oper. Prod. Manage. 31 (8), 835–850.

Galbraith, J., 1974. Organization design: an information processing view. Interfaces 4 (3), 28–36.

Gimenez, C., Sierra, V., Rodon, J., 2012. Sustainable operations: their impact on the triple bottom line. Int. J. Prod. Econ. 140 (1), 149–159.

Grant, R.M., Baden-Fuller, C., 1995. A knowledge-based theory of inter-firm collaboration. Acad. Manage. J., 17–21.

Größler, A., Grübner, A., 2006. An empirical model of the relationships between manufacturing capabilities. Int. J. Oper. Prod. Manage. 26 (5), 458–485.

Hall, W.K., 1980. Survival strategies in a hostile environment. Harv. Bus. Rev., 75–80.

Hall, R.W., Nakane, J., 1990. Flexibility: Manufacturing Battlefield of the '90s: Attaining Manufacturing Flexibility in Japan and the United States, Association for Manufacturing Excellence, Wheeling, IL.

Hambrick, D.C., 1983. High profit strategies in mature capital goods industries: a contingency approach. Acad. Manage. J. 26, 687–707.

Hayes, R.H., Pisano, G.P., 1994. Beyond world class: the new manufacturing strategy. Harv. Bus. Rev. 72 (1), 77–86.

Hayes, R.H., Wheelwright, S.C., 1984. Restoring our Competitive Edge—Competing Through Manufacturing. John Wiley & Sons, New York, NY.

Hayes, R.H., Wheelwright, S.C., Clark, K.B., 1988. Dynamic Manufacturing: Creating the Learning Organization. The Free Press, New York, NY.

Huo, B., Zhao, X., Lai, F., 2014. Supply chain integration: antecedents and consequences. IEEE Trans. Eng. Manage. 61 (1), 38–54.

Jabar, J., Soosay, C., Santa, R., 2011. Organizational learning as an antecedent of technology transfer and new product development. J. Manuf. Technol. Manage. 22 (1), 25–45.

Jack, E.P., Raturi, A., 2002. Sources of volume flexibility and their impact on performance. J. Oper. Manage. 20 (5), 519–548.

Jacobs, F.R., Chase, R., 2010. Operations and Supply Management. McGraw-Hill.

Jones, G.R., Butler, J.E., 1988. Costs, revenue, and business-level strategy. Acad. Manage. Rev. 13 (29), 202–213.

Joreskog, K.G., Sorbom, D., 1989. A Guide to the Program and Application. SPSS Inc, Chicago p. 7 (LISREL).

Konecny, P.A., Thun, J.H., 2011. Do it separately or simultaneously—an empirical analysis of a conjoint implementation of TQM and TPM on plant performance. Int. J. Prod. Econ. 13 (2), 496–512.

Koufteros, X.A., Vonderembse, M.A., Doll, W.J., 1998. Developing measures of timebased manufacturing. J. Oper. Manage. 16 (1), 21–41.

Kotha, S., Orne, D., 1989. Generic manufacturing strategies: a conceptual synthesis. Strategic Manage. J. 10 (3), 211–231.

Lee, H., Kelley, D., 2008. Building dynamic capabilities for innovation: an exploratory study of key management practices. R&D Manage. 38 (2), 155–168.

Lee, P.K.C., To, W.M., Yu, B.T.W., 2013. Team attributes and performance of operational service teams: an empirical taxonomy development. Int. J. Prod. Econ. 142 (1), 51–60.

Leonard-Barton, D., 1992. Core capabilities and core rigidities: a paradox in management new product development. Strategic Manage. J. 13 (5), 111–125.

Lewis, M., Brandon-Jones, A., Slack, N., Howard, M., 2010. Competing through operations and supply: the role of classic and extended resource-based advantage. Int. J. Oper. Prod. Manage. 30 (10), 1032–1058.

Li, S., Rao, S.S., Ragu-Nathan, T.S., Ragu-Nathan, B., 2005. Development and validation of a measurement instrument for studying supply chain management practices. J. Oper. Manage. 23 (6), 618–641.

Liu, G., McKone-Sweet, K., Shah, R., 2009. Assessing the performance impact of supply chain planning in net-enhanced organizations. Oper. Manage. Res. 2, 33–43.

Mackelprang, A.W., Nair, A., 2010. Relationship between just-in-time manufacturing practices and performance: a meta-analytic investigation. J. Oper. Manage. 28 (4), 283 (–02).

MacCallum, R.C., Browne, M.W., Sugawara, H.M., 1996. Power analysis and determination of sample size for covariance structure models: practical issues.

Martínez-Costa, M., Choi, T.Y., Martínez, J.A., Martínez-Lorente, A.R., 2009. ISO 9000/1994, ISO 9001/2000 and TQM: the performance debate revisited. J. Oper. Manage. 27 (6), 495–511.

Matsui, Y., 2007. An empirical analysis of just-in-time production in Japanese manufacturing companies. Int. J. Prod. Econ. 108 (1–2), 153–164.

McKone, K.E., Schroeder, R.G., Cua, K.O., 2001. The impact of total productive maintenance practices on manufacturing performance. J. Oper. Manage. 19 (1), 29–58.

McKone-Sweet, K., Lee, Y., 2009. Development and analysis of a supply chain strategy taxonomy. J. Supply Chain Manage. 45 (3), 2–24.

Mishra, A.A., Shah, R., 2009. In union lies strength: collaborative competence in new product development and its performance effects. J. Oper. Manage. 27, 324–338.

Morash, E.A., Clinton, S.R., 1997. The role of transportation capabilities in international supply chain management. Transp. J. 36 (3), 5–17.

Nakane, J., 1986. Manufacturing Futures Survey in Japan. Waseda University, System Science Institute, Tokyo.

Narasimhan, R., Swink, M., Kim, S.W., 2005. An exploratory study of manufacturing practices and performance interrelaitonships: implications for capability progression. Int. J. Oper. Prod. Manage. 25 (10), 1013–1033.

Narasimhan, R., Schoenherr, T., 2013. Revisiting the progression of competitive capabilities: results from a repeated cross-sectional investigation. Int. J. Prod. Res. 41 (22), 6631–6650.

New, C., 1992. World class manufacturing versus strategic trade-offs. Int. J. Oper. Prod. Manage. 12 (6), 19–31.

Noble, M.A., 1995. Manufacturing Strategy: Testing the Cumulative Model in a Multiple Country Context. Decis. Sci. 26 (5), 693–721.

Nunnally, J., 1978. Psychometric Theory. McGraw-Hill, New York, NY.

Phillips, L.W., Chang, D.R., Buzzell, R.D., 1984. Product quality, cost position and business performance: a test of some key hypotheses. J. Marketing 47, 26–43.

Porter, M.E., 1985. Competitive advantage. The Free Press, New York, NY.

Porter, M.E., 1981. The contributions of industrial organization to strategic management. Acad. Manage. Rev. 6 (4), 609–620.

Prajogo, D.I., Sohal, A.S., 2006. The integration of TQM and technology and R&D management in determining organizational performance—an Australian perspective. Omega 34 (3), 296 (-12).

Rehder, R.R., 1989. Japanese transplants: in search of a balanced and broader perspective. Columbia J. World Bus. 24 (4), 17–28.

Robinson, R.B., Pearce, J.A., 1988. Planned patterns of strategic behavior and their relationship to business unit performance. Strategic Manage. J. 9 (1), 43–60.

Romano, P., 2002. Impact of supply chain sensitivity to quality certification on quality management practices and performances. Total Qual. Manage. 13 (7), 981–1000.

Rosenzweig, E.D., Easton, G.S., 2010. Tradeoffs in manufacturing: a meta-analysis and critique of the literature. Prod. Oper. Manage. 19 (2), 127–141.

Rosenzweig, E.D., Roth, A.V., 2004. Towards a theory of competitive progression: evidence from High-Tech manufacturing. Prod. Oper. Manage. 13 (4), 354–368.

Roth, A.V., 1996a. Competitive progression theory: explanation and evidence. In: Voss, C.A. (Ed.), Manufacturing Strategy: Operations Strategy in a Global Context: Papers Frintge Third International Conference of the EUROMA, London, pp. 563–568.

Roth, A.V., 1996b. Achieving strategic agility through economies of knowledge. Strategy Leadersh. 24 (2), 30–36.

Rothaermel, F.T., Hess, A.M., 2007. Building dynamic capabilities: innovation driven by individual-, firm-, and network-level effects. Organ. Sci. 18 (6), 898–921.

Safizadeh, M., Ritzman, L., Mallick, D., 2000. Alternative paradigms in manufacturing strategy. Prod. Oper. Manage. 9 (2), 111–127.

Sakakibara, S., Flynn, B.B., Schroeder, R.G., Morris, W.T., 1997. The impact of just in time manufacturing and its infrastructure on manufacturing performance. Manage. Sci. 43 (9), 1246–1257.

Sawhney, R., 2013. Implementing labor flexibility: a missing link between acquired labor flexibility and plant performance. J. Oper. Manage. 31 (1–2), 98–108.

Sawhney, R., Piper, C., 2002. Value creation through enriched marketing-operations interfaces: an empirical study in the printed circuit board industry. J. Oper. Manage. 20 (3), 259–272.

Schroeder, R.G., Shah, R., Peng, D.X., 2011. The cumulative capability ‘sand cone’ model revisited: a new perspective for manufacturing strategy. Int. J. Prod. Res. 49 (16), 4879–4901.

Schonberger, R.J., 1986. World Class Manufacturing: The Next Decade. Free Press, New York, NY.

Schmenner, R.W., 2012. Getting and Staying Productive: Applying Swift, Even Flow to Practice. Cambridge University Press, Cambridge, UK.

Schmenner, R.W., Swink, M.L., 1998. On theory in operations management. J. Oper. Manage. 17 (1), 97–113.

Schreyogg, G., Kleisch-Eberl, M., 2007. How dynamic can organizational capabilities be? Towards a dual-process model of capability dynamization. Strategic Manage. J. 23 (2), 105–117.

Shah, R., Ward, P.T., 2003. Lean manufacturing: context, practice bundles, and performance. J. Oper. Manage. 21, 129–149.

Shah, R., Ward, P.T., 2007. Developing measures of lean production. J. Oper. Manage. 25 (4), 785–805.

Sheffi, Y., Rice, J.B., 2005. A supply chain view of the resilient enterprise. MIT Sloan Manage. Rev. 47 (1), 41–48.

Sila, I., 2007. Examining the effects of contextual factors on TQM and performance through the lens of organizational theories: an empirical study. J. Oper. Manage. 25 (1), 83–109.

Sim, K.L., Curatola, A.P., 1999. Time-based competition. Int. J. Qual. Reliab. Manage. 16 (7), 659–674.

Skinner, W., 1969. Manufacturing—missing link in corporate strategy. Harv. Bus. Rev. 47 (3), 136–145.

Snell, S.A., Dean, J.W., 1992. Integrated manufacturing and human resource management: a human capital perspective. Acad. Manage. J. 35 (3), 467–504.

Swink, M., Narasimhan, R., Kim, S.W., 2005. Manufacturing practices and strategy integration: effects on cost efficiency, flexibility, and market-based performance. Decis. Sci. 36 (3), 427–475.

Swink, M., Way, M.H., 1995. Manufacturing strategy: propositions, current research, renewed directions. Int. J. Oper. Prod. Manage. 15 (7), 4–26.

Teece, D.J., Pisano, G., Schuen, A., 1997. Dynamic capabilities and strategic management. Strategic Manage. J. 18 (7), 509–533.

Voss, C.A., 2003. Rethinking paradigms of service: service in a virtual environment. Int. J. Oper. Prod. Manage. 23 (1), 88–104.

Wacker, J., 1996. A theoretical model of manufacturing lead times and their relationship to manufacturing goal hierarchy. Decis. Sci. 27 (3), 483–518.

Wanous, J.P., Reichers, A.E., Hudy, M.J., 1997. Overall job satisfaction: how good are single-item measures? J. Appl. Psychol. 82 (2), 247–252.

White, G.P., 1996. A survey and taxonomy of strategy-related performance measures for manufacturing. Int. J. Oper. Prod. Manage. 16 (3), 42 (–1).

Wu, S.J., Melnyk, S.A., Flynn, B.B., 2010. Operational capabilities: the secret ingredient. Decis. Sci. 41 (4), 721–754.

Zahra, S.A., George, G., 2002. Absorptive capacity: a review, reconceptualization, and extension. Acad. Manage. Rev. 27 (2), 185–203.

Zhao, L., Huo, B., Sun, L., Zhao, X., 2013. The impact of supply chain risk in supply chain integration and company performance: a global investigation. Supply Chain Manage. 18 (2), 115–131.