Modeling management behaviors in lean production environments

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Abstract

Purpose – The purpose of this paper is to identify and empirically validate a repertoire of management behaviors associated with the adoption of lean systems, showing how a subset of such behaviors differentiates more advanced lean systems in a specific setting.
Design/methodology/approach – The study applies regression analysis and non-parametric hypothesis testing to an original data set coming from field research of 26 cases of adoption of lean operations practices.
Findings – The study: identifies in the lean literature a repertoire of management behaviors that support lean implementations and complement the adoption of lean practices; provides a way to operationalize them; validates this repertoire of behaviors; and shows that a subset of these behaviors is associated with more advanced lean implementations, suggesting the necessity to adopt a situational approach to lean leadership.
Research limitations/implications – The findings have boundary conditions, defined by the national, industrial, and size context in which the study was conducted.
Practical implications – The study provides practical guidance for lean system implementation suggesting a repertoire of management behaviors within which firms can identify and validate specific, appropriate subsets of behaviors aligned with the company strategy, culture, size, environment, bundle of lean operation practices adopted, and maturity stage of lean adoption.
Originality/value – This is the first study to provide quantitative, non-anecdotal evidence of the relationship between specific management behaviors and the successful implementation of lean operations practices. It offers a novel method to operationalize and measure lean management behaviors.

Keywords Management behaviours, Lean leadership, Lean operations

Paper type Research paper

1. Introduction

Understanding the determinants of the successful adoption of practices derived from the Toyota production system has progressively improved in the last two decades (Hines *et al.*, 2004; Holweg, 2007; Stone, 2012). Initially, the focus was on the performance effects from the application of one or just a few lean operations practices (Womack *et al.*, 1990) such as visual management, pull systems, cell-based manufacturing, total quality management, or total productive maintenance. Later, scholars' attention progressively shifted to how the integrated implementation of such practices, especially if associated with the adoption of high involvement human resource practices, makes a difference performance-wise and makes synergistic effects possible (MacDuffie, 1995; Spear and Bowen, 1999; Shah and Ward, 2003; Beauvallet and Houy, 2010; Lewis, 2000). More recently, practitioner-oriented literature has paid increasing attention to the role of management in lean production systems and, more specifically, to the characteristics of the management system that supports the successful adoption of lean operation practices (Shook, 2008; Rother, 2009), as well as to the competencies, leadership traits, and behaviors of managers in lean environments (Emiliani, 1998, 2003; Liker, 2004; Liker and Meier, 2007; Liker and Hoseus, 2008; Mann, 2012; Rother, 2009; Womack, 2011; Byrne, 2012; Liker and Convis, 2012; Liker and Ballé, 2013).

This increasing attention has gone hand-in-hand with the rise of behavioral operations management research (Loch and Wu, 2007; Gino and Pisano, 2008; Bendoly *et al.*, 2010),

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which questions the traditional rational behavior assumption about human beings participating in operating systems, and seeks to understand the micro-foundations of such behaviors. To date, however, with few exceptions (Van Dun *et al.*, 2017), there has been neither specific theorizing nor a quantitative, empirical investigation about the management behaviors associated with the successful adoption of lean operations practices.

This study seeks to fill this research gap by: identifying a repertoire of management behaviors, drawn from the lean operations literature, that can be used as an initial reference for "lean" scholars and practitioners to understand which management behaviors support the successful adoption of lean operations practices; providing a method to operationalize and measure these behaviors, their presence, and level of intensity; validating these behaviors by testing whether and to what extent their presence and intensity are actually correlated with the level of adoption of lean operation practices; and suggesting – using a specific research setting as an example – that different subsets of lean management behaviors (LMBs) might characterize a more advanced adoption of lean operation practices contingent upon the external context, the firm's strategy, culture and size, and the stage of implementation of the lean system.

2. Theory and research hypotheses

2.1 LMBs: a literature review

Lean production is conceived of as "a multi-dimensional approach that encompasses a wide variety of management practices, including just-in-time, quality systems, work teams, cellular manufacturing, supplier management, etc. in an integrated system" (Shah and Ward, 2003, p. 129). This perspective also acknowledges that the heart of lean does not lie in the application of lean operations practices – and the associated tools and artifacts – but, rather, in a business philosophy able to continuously improve organizational process performance while at the same time developing people capabilities (Liker, 2004; Fine *et al.*, 2008).

Following this line of reasoning, some studies point to the importance of managers' behaviors as key enablers of successful adoption of lean operation practices. For example, De Menezes *et al.* (2010) provide empirical evidence for the existence of a firm's "underlying philosophy" through which human resources and operations management behaviors combine lean operations and high-involvement work practices. From this perspective, lean operation practices are the visible manifestations of the underlying philosophy, which is enacted by a set of specific management behaviors. Similarly, Shah and Ward (2007) define lean production as an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability. This definition is consistent with the idea that management "orchestrates" lean systems (Hopp and Spearman, 2004; De Treville and Antonakis, 2006). Also, the studies highlighting the difficulties in imitating the Toyota production system (Womack *et al.*, 1990; Safayeni *et al.*, 1991; Liker, 2004) explicitly refer to the importance of management behaviors for a successful transition to lean systems. Similarly, it has been highlighted that poor leadership may be an important cause of non-sustainable processes in the adoption of lean operation practices (Lucey *et al.*, 2005; Found and Harvey, 2006; Hines *et al.*, 2011).

Overall, the importance of appropriate management behaviors and leadership in the adoption of lean operation practices has been acknowledged by several studies in various industry settings. These studies also typically offer some LMBs' repertoires (Bateman, 2005; Emiliani, 2003, 2008; Lucey *et al.*, 2005; Found and Harvey, 2006; Fine *et al.*, 2008; Koenigsaecker, 2009; Hines *et al.*, 2011; Byrne, 2012; Mann, 2012). However, most of these studies are case-based, rely on anecdotal evidence, and provide insights that are difficult to generalize. They offer neither quantitative empirical data nor replicable research protocols or appropriate metrics. The former aspect is partly due to the fact that many of the above

studies have been conducted by practitioners and targeted to the practitioner-oriented public, as well as to the fact that it is difficult to integrate lean operations literature with leadership and management literature. The latter aspect is especially important for the advancement of the lean operations literature since management behaviors represent one of the micro-foundations of lean production systems (the other being workers' behaviors) and of the associated operational routines/practices (Bendoly *et al.*, 2006).

Overall, management behaviors have increasingly been considered important for the successful adoption of lean systems, but are more difficult to observe, study, and replicate than the lean operation practices embodied in visible routines or artifacts. This difficulty also helps to explain why LMBs are comparatively under-investigated, and, consequently, why lean production systems tend to be considered a set of tools and practices (Lander and Liker, 2007).

Among the LMBs' repertoires available in the literature, Womack and Jones (2005) and Womack (2011) describe the value-creating work of management in lean environments as the routine activity of aligning people and processes with customer purpose. This perspective points to a view of management that is characterized by behaviors such as responsibility (or "pull-based" authority) over end-to-end processes (Ohno, 1988; Shook, 2008); decision-making based on evidence (Liker, 2004; Pfeffer and Sutton, 2000, 2006); the application of the scientific method and of the experimental approach to organizational problem-solving (Deming, 1986; Spear and Bowen, 1999); the recognition that, to pursue ambitious organizational purposes through complex processes, people in organizations need to be taught and coached rather than directed (Liker and Convis, 2012; Liker and Ballé, 2013); and the acknowledgment that knowledge and ingenuity are implicit and dispersed in organizations and need to be tapped into and mobilized from the bottom-up (Nonaka and Takeuchi, 1995; Rother, 2009). Accordingly, Womack (2011) contrasts a set of differences between the management behaviors that can be associated with a supposedly "traditional" management system and those that can be associated with a supposedly "lean" management system. He derives a repertoire of LMBs that largely overlaps with those proposed by other scholars (Emiliani, 2003; Mann, 2012).

Anand *et al.* (2009) relate this conceptualization of management with the development of continuous improvement strategies and apply the "purpose-process-people" model to analyze and decompose lean management systems. From this perspective, continuous improvement is a firm's dynamic capability (Fujimoto, 1999; Anand *et al.*, 2009), nurtured by specific management behaviors and supported by coherent organizational infrastructures that allow an organization to systematically and successfully introduce changes in operational routines.

Mann (2012) takes a slightly different perspective and points out that leadership is the bridge between lean operations practices, tools, and artifacts and lean principles, focusing on the role managers should play in order to guarantee consistency among these factors and, hence, the successful adoption of lean operations practices. In the same vein, other case studies (Poksinska *et al.*, 2013) show that many management behaviors exhibited by managers in lean environments can be classified as transformational leadership behaviors (Bass and Avolio, 1994). These behaviors, which imply supporting and helping, active listening, and showing respect for others' work, largely resemble those included in Greenleaf's (2002) model of servant leadership and echo Collins' (2001) concept of humility, characterizing his "Level 5" leadership.

2.2 Research hypotheses

As above described, some studies hint at the fact that LMBs might co-vary with the stage of adoption of lean operation practices, and that contextual variables might moderate such a relationship (De Menezes *et al.*, 2010; Angelis *et al.*, 2011). In the same vein, Mann (2012)

suggests that different behaviors might be more important at different stages of the implementation of lean initiatives, with appropriate management behaviors becoming, for example, a driver of cultural change or a source of culture reinforcement and, hence, prevent regression to traditional habits.

However, the role of management behaviors in the successful adoption of lean operation practices has been highlighted as a critical issue, but, to date, nobody has: systematized these behaviors; rigorously documented if and to what extent these behaviors are associated with lean operation practices adoption; or clarified the contingencies that might moderate the relationship between management behaviors and lean operation practices adoption. This is largely due to the fact that such behaviors are: difficult and expensive to observe and study (interviews, direct observation, and extensive field studies are required Van Dun *et al.*, 2017); complex to measure (at least compared with the already complex practice – widespread in the lean operations empirical research – to use self or third party assessments with regard to the level of adoption of lean artifacts, tools, and practices Camacho-Minano *et al.*, 2013); difficult to relate to the "hard" and visible part of lean systems (tools, artifacts, practices) because of causal ambiguity and social complexity; and out of the traditional scope of lean literature, which is rooted in operations management but has remained so far segregated from human resource, organization, and leadership theory (Loch and Wu, 2007; Bendoly *et al.*, 2010).

This study aims at taking a further step along this line of investigation by identifying a repertoire of behaviors, derived from the literature, that characterize the value-creating work of management in lean environments, and how these behaviors support the adoption of lean operation practices. Our research design adapts the literature on managerial competency modeling, defined as the identification of regular behavioral patterns (Shippmann *et al.*, 2000; Campion *et al.*, 2011) and proceeds as follows. First, using the repertoire of LMBs derived from a review of the lean literature described in the previous section, we elaborate a research protocol to empirically investigate these behaviors and provide a methodology to assess whether and to what extent managers of firms adopting lean operations practices exert these behaviors. Second, we try to empirically validate this repertoire of behaviors, testing whether their presence (the extent to which they are practiced by managers) is stronger in firms with higher levels of adoption of lean operation practices (as defined by the stream of literature on lean assessment and on the maturity stages of lean adoption (Soriano-Meier and Forrester, 2002; Shah and Ward, 2007; Bhasin, 2011; Wong *et al.*, 2012; Camacho-Minano *et al.*, 2013). Thus, it is hypothesized that:

H1. The degree of adoption of the repertoire of management behaviors derived from the lean operations literature is positively related with the level of adoption of lean operation practices.

Third, we propose adopting a situational approach suggesting that, although there is a general repertoire of management behaviors that positively co-vary with the level of adoption of lean operation practices (*H1*), different subsets of these behaviors are typically associated with different levels of adoption of lean operation practices, and that different bundles of LMBs might correlate with the adoption of lean operation practices contingent upon the external context, the firm's strategy, culture and size, the stage of implementation of the lean system, and the bundle of lean operation practices adopted (Hines *et al.*, 2011). More specifically, we focus on testing the hypothesis according to which, in a specific setting, a subset of behaviors differentiates more advanced lean adopters. Thus, it is hypothesized that:

H2. Given a specific setting, firms with higher levels of adoption of lean operation practices are characterized by higher adoption of a specific subset of LMBs derived from the lean operations literature.

3. Research constructs, measures, and method

3.1 The level of adoption of lean operation practices

3.1.1 Construct. We test our hypotheses by setting the level of adoption of lean operation practices as the dependent variable. This variable is intended to capture the degree of maturity of the lean production system in place and to operationalize Shah and Ward's (2007) definition of lean production as an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability in supply, processing time, and demand (Hopp and Spearman, 2004; De Treville and Antonakis, 2006). In order to do so, we follow Shah and Ward's (2007, p. 799) operationalization and use the ten factors that they identify (Table I). We further operationalize these ten dimensions by adjusting and adapting their relevant measurement items in order to fit our research design and method. We ended up with 19 survey items that, building upon Shah and Ward's (2007), also take into account recent developments in the lean operations' "assessment" literature (Soriano-Meier and Forrester, 2002; Bhasin, 2011; Saurin *et al.*, 2011; Camacho-Minano *et al.*, 2013).

The underlying assumptions of this line of research follow the integrated, holistic approach suggested by recent studies on "Lean Indexes" (Wong *et al.*, 2012), and is further characterized by: the necessity to assess both the breadth and depth of application of the various observable components of lean management systems; and the necessity to use research methods that rely on the direct observation of the operations in order to get a thorough and comprehensive understanding of the degree of adoption of the various lean operations practices together with an appreciation of the overall level of maturity of the lean production system in place.

3.1.2 Data gathering. We measured the level of adoption of lean operation practices as the mean value of the scores deriving from an on-site assessment, conducted through an extensive company visit by a sub-team of three researchers, on the set of 19 items reported in Table I. These 19 items were included in a purposely built research protocol and used by the research team during the fieldwork.

Each researcher within the sub-team had more than ten years of experience assessing lean systems, and independently assessed each company in the sample during an extensive "gemba walk" in the main production, R&D and engineering, purchasing and supply chain management facilities, asking questions to the managers, engineers, and workers, observing the operations, the technologies, the facilities, and the other relevant artifacts. The visit lasted one day and the date was agreed upon by the companies' top managers, making sure it represented a "normal" workday. Each item/set of lean operation practices was evaluated on a 1-5 scale (1 = low degree of advancement; 5 = high degree of advancement). The research protocol also specified, for each level of each item, what the operations should look like and what artifacts, tools, and people's behaviors should be observable at the different levels of the evaluation scale, in order to collect fact-based information and avoid managers' general opinions. The individual assessments conducted by the researchers were then compared (item by item) to evaluate the inter-rater reliability and to converge on a shared assessment of each analyzed firm and a corresponding final assessment.

3.1.3 Measure. On the basis of the field assessments, for each analyzed firm we computed the overall average level of adoption of lean operations practices (lean advancement index: LA):

$$\mathrm{LA} = \frac{\sum_1^n V_i}{n} \tag{1}$$

where V_i is the value associated with each of Shah and Ward's ten dimensions (ranging

Shah and Ward's (2007) dimensions of lean systems	Number of items and description	Cronbach's α
Controlled process	(1) The root cause and countermeasures of all problems are identified through an established problem solving methodology	0.704
	(2) Visual displays for monitoring processes and pokayoke systems to automatically stop "out-of-control" processes are used throughout the facility	
	(3) Wide range of visual management tools are used throughout the facility	
	(4) There are clear line stop procedures in place and operators are empowered to stop the line the instant an abnormality occurs	
Involved employees	(1) Decision-making across the enterprise is delegated to the point of application	0.742
	(2) Formal 5S improvement activities are in place according to plant improvement plans and targets	
	(3) Every area of the company is actively working on process improvement	
	(4) Advanced knowledge training occurs and is linked to advancement opportunities	
Pull	(1) Production is driven completely by "Pull" signal from downstream processes	0.718
	(2) FIFO is applied to production lots and no material is found outside designated areas	
	(3) Right size container design principles are taken into consideration also from suppliers	
Involved customers	(1) Production is perfectly leveled to customer demand and based on Takt time	0.811
	(2) Pace of production is established based on the optimal Takt time	
Supplier feedback	(1) We use inter-networked information systems with our suppliers through the entire supply chain so that planning, scheduling, and supply is collaborative and real-time	
JIT delivery	(1) Demand is communicated to external partners primarily through pull systems based on customer demand. Material flow from supplier to customer has been maximized	
Developing suppliers	(1) We help our suppliers reach high levels of excellence. We bring innovative new products to market by creating cooperative relationships with strategic partners. We make significant use of collaborative technology	
Flow	(1) Coordinated one piece flow production occurs for all operations	
Low setup	(1) Approaches to reducing setup times are well defined and widely understood	
Productive maintenance	(1) Preventive maintenance activities are continuously improved through kaizen activities and the majority are predictive in nature	

Source: Authors' elaboration on Shah and Ward (2007)

Table I.
Level of adoption of lean operation practices. Assessment dimensions and items

from 1 to 5, in our case), and n the number of dimensions (ten) of Shah and Ward's model. The lean advancement index (LA) presented a high level of internal consistency (Cronbach's $\alpha = 0.835$).

3.2 Management behaviors in lean environments

3.2.1 Construct. In order to define LMBs as a research construct, operationalize it, and measure it rigorously, we built on the literature review presented above. More specifically, we elaborated on the repertoire of management behaviors pioneered by Emiliani (1998, 2003, 2008) and developed by Womack (2011), complementing it with the following: other

practitioner-oriented work (Bhasin and Burcher, 2006; Bicheno and Holweg, 2009; Mann, 2012; Koenigsaecker, 2009; Byrne, 2012); the few existing analytical quantitative studies conducted to date on related topics (Van Dun and Wilderom, 2016; Van Dun *et al.*, 2017); and other studies on the nature of management and leadership for sustainable performance, as developed by streams of thought and practice such as evidence-based management (Pfeffer and Sutton, 2000, 2006), Level 5 leadership (Collins, 2001), primal and resonant leadership (Goleman *et al.*, 2001), transformational leadership (Bass and Avolio, 1994), and servant leadership (Greenleaf, 2002).

Integrating the above mentioned literature, we ended up with a repertoire of 14 management behaviors, listed in Table II.

Following Womack (2011), we described these behaviors, developing behavioral indicators for each of them, which represent different levels of proficiency/presence. These detailed level descriptions – largely referable to the anchored rating scales commonly used in the leadership and managerial competency literature (Campion *et al.*, 2011) were then used to operationalize the level of adoption of such behaviors.

3.2.2 Data gathering. In order to get reliable data, we conducted behavioral interviews with the senior operations managers of the analyzed companies. This interview largely drew upon the critical incident interview technique (Flanagan, 1954) and its successive developments, such as the behavioral event interview (Boyatzis, 1998; McClelland, 1998) or the storytelling technique (Boje, 1991), where the attention of the interviewer is focused on gathering information on specific and real cases and events experienced by the interviewee and not on the interviewee's opinions and general evaluations. This interview technique has been widely used for structuring qualitative data analysis to obtain rich and detailed information on the context, behaviors, and strategies adopted to achieve particular outcomes (Chell, 2004; Campion *et al.*, 2011). For this reason, this interview technique represents a good proxy for direct observation of actual management behaviors.

For the aim of our research, we adapted this interview technique in our protocol and focused it on: significant events specifically related to the adoption of lean operation practices; and the management behaviors of all the managers involved in the events.

The interviews were conducted by a sub-team of two researchers (different from the team that made the company visits to evaluate the level of adoption of lean operation practices) with over ten years of experience conducting behavioral event interviews in firms. The interviewees were the Lean or Kaizen Promotion Office Leaders or the company's top lean agent.

Lean management behaviors	
(1) Organizational focus	Womack (2011)
(2) Managerial responsibility	Ohno (1988), Shook (2008)
(3) Basis of performance evaluation	Deming (1986), Byrne (2012), Koenigsaecker (2009), Dibia *et al.* (2014)
(4) Planning	Jackson (2006)
(5) Managerial versatility	Liker (2004), Van Dun *et al.* (2017)
(6) Managerial development	Liker and Hoseus (2008), Liker and Meier (2007)
(7) Decision making	Liker (2004), Shook (2008), Hines *et al.* (2011), Spear (2004)
(8) Problem solving	Spear and Bowen (1999), Nonaka and Takeuchi (1995), Rother (2009)
(9) Standards development	Mann (2012), Emiliani (2008), Liker and Franz (2011)
(10) Supportiveness	Liker and Convis (2012), Liker and Ballé (2013), Angelis *et al.* (2011)
(11) Managerial reflexivity	Rother (2009), Shook (2008), Womack (2011)
(12) Capability development	Liker and Convis (2012), Liker and Ballé (2013), Poksinska *et al.* (2013), Van Dun and Wilderom (2016)
(13) Managerial mindset	Rother (2009), Found and Harvey (2006)
(14) Challenge	Emiliani (2003, 2008), Bhasin and Burcher (2006)

Table II. Repertoire of lean management behaviors derived from the literature

These features of the research design (separate sub-teams of researchers, different methods and respondents, lagged independent and dependent variables) were aimed at preventing problems of endogeneity (reverse causality and spurious correlations) as well as measurement errors in the dependent and independent variables due to single respondent bias (Podsakoff *et al.*, 2003). The interview protocol used by the team of interviewers included a standardized, five-section interview. Section 1 of the interview protocol investigated the motivation and start of the "lean journey" of the company and was aimed at describing the initial implementation of lean operation practices in the firm. Section 2 explored the process of adoption of the lean operations practices, investigating the first lean operation practice that was adopted and the associated process. Section 3 investigated the first significant performance improvements obtained thanks to the adoption of lean operation practices. Section 4 entailed the narration of two specific events where the adoption of lean operation practices led to significant performance improvements. Section 5 entailed the narration of one specific event in which the adoption of lean operation practices led to significant disruptions, problems, a worse performance, or unexpected outcomes.

Each interview lasted approximately 1.5 hours. All the interviewees were informed of the purpose of the research and gave written consent to use the data. The interviews were tape-recorded and transcribed in their entirety for subsequent coding. Subsequently, each interview was analyzed with the purpose of detecting the presence of the above-defined LMBs and interpreting the strength/intensity of such presence using the behavioral indicators as the coding scheme. This analysis was conducted independently by two different researchers who individually coded the interviews for the frequency of occurrence of the above-defined LMBs. The inter-rater reliability estimates showed a high level of agreement (Cohen's $\kappa = 0.89$). In case of disagreement, the researchers analyzed the interview transcription together and discussed the underlying behavioral intent of the interviewee from the overall description of the event. A final decision about coding was then made.

3.2.3 Measure. In our hypotheses, the extent to which managers practice the LMBs identified above represents the independent variable.

In order to operationalize and measure these behaviors, we started from the above discussed approach that contrasts a supposedly "traditional" management system with a supposedly "lean" management system (Emiliani, 2003; Womack, 2011; Mann, 2012) and built a small set of behavioral indicators for each behavior in the repertoire, which were used as anchored rating scales to assess the degree of consistency (or inconsistency) of the analyzed companies' management behaviors with those highlighted by the lean operations literature. Each of the 14 behaviors considered could be rated between −1 (if the observed management behavior corresponded to a behavioral indicator inconsistent with the lean literature) and +1 (if the observed management behavior corresponded to a behavioral indicator consistent with the lean literature). Intermediate behaviors were weighted accordingly (and linearly) in between –/+1. "Example of anchored rating scales associated to the LMB 'Planning' used to code the interviews" shows an example of the behavioral indicators and of the corresponding scales associated with the LMB labeled "Planning."

Example of anchored rating scales associated to the LMB "Planning" used to code the interviews.

Planning:

Managers lead their organization and guide subordinates' actions:

(1) −1. Prevalently through rigid plans, grounded on the budgeting process, that establish targets, cascade them throughout the organizational structure, describe solutions and tools, provide incentives to get it done, set deadlines to periodically check results (compliance focus: "Make the plan or explain the variances").

(2) 0. Prevalently through flexible plans, which, although still grounded in the budgeting process, incorporate new information rendered available. Little systematic involvement of other actors.

(3) +1. Prevalently through flexible plans, not grounded in the budgeting process, that work like rapid and frequent PDCA cycles. They revise plans engaging in "catchball" processes with their subordinates that provide the information and knowledge to do that.

The frequency of occurrence of each management behavior was calculated by counting and weighting the number of times each LMB was detected in the interview. Then, using the scaling reported in "Example of anchored rating scales associated to the LMB 'Planning' used to code the interviews", we built an index (ranging from –100 to+100) that positively weighted the presence of management behaviors associated with a more successful adoption of lean operations practices, and negatively weighted the presence of behaviors associated with a "traditional" management system. The measure for the weighted frequency of occurrence of each management behavior follows:

$$F_{i,j} = \frac{\mathrm{CB}_{i,n} W_{i,n}}{\mathrm{PB}_{i,n}}.100 \tag{2}$$

where $F_{i,j}$ is the frequency of management behavior i detected in the firm j, $\mathrm{CB}_{i,n}$ the coded behaviors: number of times that the behavioral indicator n associated with the behavior i was detected in the interview, $W_{i,n}$ the weight associated with the behavioral indicator n (from −1 to +1, according to the scaling reported in "Example of anchored rating scales associated to the LMB 'Planning' used to code the interviews") associated with the management behavior i, $\mathrm{PB}_{i,n}$ the potential behaviors: the maximum number of weighted behavioral indicators associated with behavior i detectable in the interview. This depends on the number of events gathered in an interview, since each indicator may be coded, at most, once per event, i the analyzed management behaviors (from 1 to 14), n the behavioral indicator associated with each behavior.

Our measure of the overall presence of LMBs in a firm is as follows:

$$\text{Lean management behaviors in firm } j\left(\mathrm{LMB}_j\right) = \sum_i F_{i,j} \tag{3}$$

where $F_{i,j}$ is the weighted frequency of occurrence of the management behavior i in firm j.

4. Sample

We tested our hypotheses on a sample of 26 North Italian small and medium enterprises, already fully committed and seriously engaged, though at different stages, in the adoption of lean operations practices. These firms were selected with the aid of lean experts and local employer association representatives according to the following criteria: they were companies with positive financial performance in the period 2006-2011; and they were companies that, in the same period, had made a significant commitment to and investment in the adoption of a lean system (Boyer, 1996). All of the companies included in the sample were at their first lean implementation. Out of the 26 firms included in the sample, 12 had started the adoption of lean operation practices more than five years before this study, while three of them had started it only two years before. These firms belong to diverse industrial sectors, have different sizes and ownership, and nine of them were at least partially owned by a multinational company.

5. Findings

5.1 Descriptive statistics and correlation analysis

First of all, we calculated the sample means and standard deviations of the level of adoption of lean operations practices (LA) (our dependent variable), of the LMB index (our main independent variable), and of the control variables. Second, we applied multiple regression analysis to test whether and to what extent the level of adoption of the LMB was actually associated with the level of adoption of lean operation practices (LA). Finally, after dividing the sample into sub-samples, we applied non-parametric statistical analysis to identify the management behaviors that, in the research setting, differentiate the firms with a higher level of adoption of lean operation practices.

Table III reports the descriptive statistics of the dependent, independent, and control variables.

An analysis of the descriptive statistics makes it possible to appreciate the level of presence of the LMBs in the analyzed sample, and provides some preliminary insight into lean systems in the analyzed setting. Interestingly, all but one of the management behaviors included in the repertoire present a positive weighted average frequency of occurrence, which, given the way in which the LMB measure is constructed, provides some preliminary, indirect evidence that LMBs indeed characterize lean adopters.

Not surprisingly, the LMB with the highest average weighted frequency of occurrence is decision making (33.08), which measures the extent to which managers make decisions not on the basis of data provided by reporting systems, far from the point of value creation, but on the basis of a thorough understanding of facts, directly at the point of value creation, tapping into the local knowledge of the employees involved in the operations. Similar considerations apply to other behaviors like planning (25.72), standards development (23.2), and problem solving (21.15).

Among the behaviors included in the repertoire, only challenging shows a negative average weighted frequency of occurrence (indicating "non-lean" management behaviors). This behavior is related to the managers' capability to directly involve their team in defining challenging targets to improve their achievements. In our sample, a negative frequency means the adoption of management behaviors like top-down goal setting, very stretching goals, pressure on target achievement, and focus on checking results. This may be derived from Italian peculiarities in terms of national culture (leadership style based on authority, and boss-subordinate relationships based on higher power distance), and from the specific governance/ownership structure of the analyzed firms (where family ownership and the comparatively smaller size of the firms drives the business owners' significant, active involvement in every decision and a tight control on performance outcomes).

5.2 Regression analysis and non-parametric hypotheses testing

Our first hypothesis posits that the presence of a specific set of management behaviors derived from the lean operations literature positively co-varies with the level of adoption of lean operation practices. Finding empirical support to this hypothesis would represent the first step to empirically validate the repertoire of management behaviors derived from the lean literature.

As the dependent and independent variables are time-lagged, the data were collected by different researchers with different methods and research protocols, and from different sources. Thus, we believe that issues of endogeneity (namely reverse causality) and of measurement error should be negligible, and the data should be reliable for drawing at least some meaningful statistical inferences.

Overall, we are therefore confident that the correlation coefficients reported in Table III represent actual evidence that, in the analyzed sample, there is a positive relationship between the level of adoption of lean operation practices measured by LA (lean advancement index)

Table III. Descriptive statistics and correlations

	Mean	SD	1	2	3	4	5	6	7	8	9	10
1. Decision making	33.08	24.77	1									
2. Planning	25.00	33.41	0.085	1								
3. Standards development	23.72	28.56	0.595**	0.319	1							
4. Problem solving	21.15	31.54	0.286	0.289	0.155	1						
5. Managerial reflexivity	20.19	24.04	0.073	0.429*	0.189	0.007	1					
6. Managerial versatility	19.23	48.19	−0.017	0.020	0.181	−0.015	−0.169	1				
7. Managerial development	17.42	20.31	0.119	0.373	0.445*	0.105	0.317	−0.081	1			
8. Managerial responsibility	17.31	33.80	0.235	0.128	0.471*	−0.073	0.339	−0.204	0.309	1		
9. Organizational focus	16.83	14.06	0.293	0.358	0.692**	−0.152	0.222	0.338	0.377	0.323	1	
10. Supportiveness	15.38	26.92	0.217	0.285	0.484*	−0.157	0.337	0.217	0.095	0.236	0.682**	1
11. Capability development	15.38	30.98	−0.095	0.392*	0.264	0.061	0.358	0.059	0.472*	0.174	0.307	0.024
12. Basis of performance evaluation	10.58	33.38	0.414*	0.424*	0.594**	0.198	0.393*	−0.067	0.410*	0.306	0.581**	0.461*
13. Managerial mindset	10.26	27.38	0.332	0.234	0.317	0.046	0.172	0.142	0.248	0.155	0.364	0.221
14. Challenge	−5.77	37.54	0.081	−0.064	−0.231	0.103	0.023	0.168	−0.222	−0.224	0.070	0.088
15. Lean advancement index (LA)	2.79	0.43	0.204	0.450*	0.695**	0.057	0.259	0.411*	0.388*	0.433*	0.712**	0.587**
16. Lean management behaviors index (LMB)	239.76	205.68	0.485*	0.595**	0.733**	0.293	0.483*	0.302	0.498**	0.406*	0.735**	0.566**
17. Size	2.27	0.53	0.203	0.495*	0.517**	0.004	0.332	0.405*	0.235	0.389*	0.365	0.252
18. Group	0.35	0.49	−0.123	0.020	0.198	−0.104	−0.023	0.213	−0.094	0.225	0.028	−0.115
19. Years	3.96	2.71	0.031	0.351	0.528**	−0.082	0.208	0.397*	0.398*	0.286	0.656**	0.358

	Mean	SD	11	12	13	14	15	16	17	18	19
1. Decision making	33.08	24.77									
2. Planning	25.00	33.41									
3. Standards development	23.72	28.56									
4. Problem solving	21.15	31.54									
5. Managerial reflexivity	20.19	24.04									
6. Managerial versatility	19.23	48.19									
7. Managerial development	17.42	20.31									
8. Managerial responsibility	17.31	33.80									
9. Organizational focus	16.83	14.06									
10. Supportiveness	15.38	26.92									

(*continued*)

Table III.

			11	12	13	14	15	16	17	18	19
11. Capability development	15.38	30.98	1								
12. Basis of performance evaluation	10.58	33.38	0.556**	1							
13. Managerial mindset	10.26	27.38	0.267	0.442*	1						
14. Challenge	−5.77	37.54	−0.199	0.164	0.058	1					
15. Lean advancement index (LA)	2.79	0.43	0.381	0.528*	0.217	−0.012	1				
16. Lean management behaviors index (LMB)	239.76	205.68	0.503**	0.803**	0.552**	0.173	0.749**	1			
17. Size	2.27	0.53	0.456*	0.388	0.255	−0.117	0.637**	0.612**	1		
18. Group	0.35	0.49	0.248	0.072	0.121	−0.427*	0.270	0.050	0.553**	1	
19. Years	3.96	2.71	0.241	0.320	0.235	0.075	0.729**	0.561**	0.562**	0.285	1

Notes: $n = 26$. Pearson Correlation: $^{*}p < 0.05$; $^{**}p < 0.01$

and the presence of the set of LMBs derived from the lean literature, measured by LMB index. In fact, the Pearson correlation coefficient between LA and LMB is positive (0.749) and statistically significant.

More robust evidence that the management behaviors often reported to support the adoption of lean operation practices are empirically correlated with them is provided by regression analysis. We ran two regressions, with LA as a dependent variable and LMB as an independent variable, and a set of control variables that may also affect the level of adoption of the lean operation practices. The first control variable was the size of the firm, which may positively affect the degree of advancement of the lean transformation because of economies of scale and a larger investment in lean infrastructures (Boyer, 1996). The second was the different ownership structures, as proxied by the fact that the firm might be family-owned or at least partially owned by a multinational group, which may positively affect LA because faster and easier learning comes from the possibility to leverage on the support provided by headquarters and on the corporate-wide lean management system. The third control variable was the duration of the "lean journey," expressed by the time elapsed since the beginning of the adoption of lean operation practices, which obviously should positively affect LA because of learning effects. With regard to firm size, we used company revenues as a proxy, classifying the sampled firms into three size categories (less than 10 million euros, from 10 to 50 million euros, more than 50 million euros). In order to control for the ownership structure, we used a dummy variable, which takes value 0 if the firm is a stand-alone, autonomous business, or 1 if it is financially controlled by a larger group. With regard to the duration of the "lean journey," we used the number of years since the start of the adoption of the lean operations practices.

We ran two ordinary least squares models, shown in Table IV.

Model 1 shows that our control variables have the hypothesized positive effects on the level of adoption of lean operation practices, with the exception of the control variable "Group" (ownership type), which has no effect (size has a regression coefficient $\beta = 0.389$; $p = 0.046$, and the duration of the lean journey has a regression coefficient $\beta = 0.538$; $p = 0.003$). Model 2 adds the independent variable LMB to the controls, which positively and significantly impacts the level of adoption of the lean operation practices ($\beta = 0.481$; $p = 0.012$). In this second model, the size effect vanishes while the regression coefficient of the duration of the "lean journey" remains positive and significant ($\beta = 0.393$; $p = 0.016$). This is consistent with the fact that the control variable Size is positively and significantly correlated not only with the control variables Group and Years but also with LMB. This makes sense as we would expect larger firms to exert leverage on economies of scale, also in terms of developing a managerial structure more consistent with lean operation practices. Overall, our estimates support the first hypothesis.

With regard to our second research hypothesis, we tested whether a sub-repertoire of the identified LMBs might work as differentiators between more and less advanced lean adopters. Testing this research hypothesis is particularly important to contextualize the

	Model 1 Std. β (sig.)	Model 2 Std. β (sig.)
LMB		0.481 (0.012)
Size	0.389 (0.046)	0.069 (0.733)
Group	−0.098 (0.542)	0.096 (0.546)
Years	0.538 (0.003)	0.393 (0.016)
Adjusted R^2	0.561	0.663

Notes: $n = 26$. Level of adoption of the lean operation practices (LA) as dependent variable

Table IV.
OLS results for *H1*

analysis and avoid the risk of adopting a "one-size-fits-all" approach (a universally valid repertoire of "LMBs"), which is somehow implicit in part of the extant literature. Following this situational approach, our second hypothesis posits that some LMBs might be more important than others to support lean implementation, contingent upon a variety of factors. In order to investigate which of the analyzed management behaviors differentiate firms with higher levels of adoption of lean operation practices in a given context, we built on and adapted competency and managerial behaviors' modeling techniques (Boyatzis, 1998; Campion *et al.*, 2011). We divided our sample into two sub-samples (one of "advanced" and another of "followers" lean operations practices adopters) using the sample average of the dependent variable LA as splitting criterion. We ended up with two subsamples: "advanced" lean firms ($n = 13$) characterized by above average levels of adoption of lean operation practices (values of LA); "followers" lean firms ($n = 13$) characterized by below average levels of adoption of lean operation practices (values of LA). We then compared the frequency distributions of the analyzed LMBs of the two sub-samples and tested the alternative hypothesis that the weighted frequency of occurrence of the management behaviors for the "advanced lean adopters" sub-sample is larger than the weighted frequency of occurrence of the management behaviors for the "followers lean adopters" sub-sample. Since no assumption can be made about the distribution of the population of the two sub-samples and given the small sample size, we used non-parametric statistical analysis (Mann-Whitney *U* test). As a result, we identified a subset of LMBs that differentiate the most advanced lean adopters from the others. This analysis is reported in Table V. Our results support the second hypothesis.

There are six management behaviors in this subset. The first is Standards development. The best lean adopters distinguish themselves because their managers do not micromanage. Instead, they develop work and other types of standards in collaboration with their teams and use them as a baseline for continuous improvement (Adler, 1993).

The second behavior is Managerial versatility. The more advanced lean adopters distinguish themselves because their managers prevalently operate on extended assignments, with in-depth process and people knowledge. They are not mere generalist coordinators of resources, frequently rotating on assignments.

The third behavior is Organizational focus. Managers of more advanced lean adopters have a horizontal organizational focus. Instead of concentrating on narrowly defined

Lean management behaviors	Weighted frequency of occurrence % "Advanced" adopters	"Followers" adopters	Mann-Whitney *U* test *Z* values[a]	Distinctive
Decision making	32.31	33.85	0.08	
Planning	34.62	15.38	1.27	
Standards development	37.18	10.26	2.85***	✓
Problem solving	26.92	15.38	1.1	
Managerial reflexivity	23.08	17.31	0.33	
Managerial versatility	38.46	0.00	1.99**	✓
Managerial development	23.05	11.78	1.01	
Managerial responsibility	23.08	11.54	1.17	
Organizational focus	21.63	12.02	1.69**	✓
Supportiveness	23.08	7.69	1.36*	✓
Capability development	30.77	0.00	2.52***	✓
Basis of performance evaluation	25.00	−3.85	2.30***	✓
Managerial mindset	15.38	5.13	1.18	
Challenge	−7.69	−3.85	0.45	

Notes: Sub-set of lean management behaviors differentiating firms with higher level of adoption of lean operation practices. [a]*Z* values for Mann-Whitney *U* Test, one tailed. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table V.
Non-parametric hypothesis test results for *H2*

functional issues, they pay more attention to the horizontal flow of value along entire value streams or the whole supply chain, across different departments and organizations.

The fourth behavior is Supportiveness. Managers of more advanced lean adopters tend to consider their role in terms of help to their team members. As such, they see themselves at the service of value-creating work and spend a large amount of their time genuinely worrying about the needs of their collaborators.

The fifth behavior is Capability development. The managers of firms with higher levels of adoption of lean operation practices tend to act as the teachers and coaches of their teams significantly more than their counterparts in less advanced lean adopters.

The sixth behavior is Basis of performance evaluation. Managers of companies with more advanced applications of lean operation practices tend to evaluate performance by referring to the state of the processes they are responsible for, with rapid and frequent feedback loops with next-level management.

6. Discussion and implications

With regard to the first hypothesis, this study provides, for the first time, systematic and quantitative evidence that a stronger presence of the LMBs typically referred to by the extant lean literature is associated with higher levels of adoption of lean operation practices. This represents a first step toward the empirical validation of a repertoire of management behaviors usually assumed by the lean literature to be complementary with lean operations practices, and a move beyond the anecdotal evidence often provided, to date, by extant studies.

With regard to the second hypothesis, our empirical findings might contribute to the development of a theory of lean management and leadership in two ways. The first is grounded in the adoption of a situational approach to lean systems that need to be not only internally consistent, but also externally aligned (Azadegan *et al.*, 2013; Marodin and Saurin, 2015). The fact that we find six management behaviors that work as best lean adopters' differentiators in a specific setting suggests that, most likely, different sets of behaviors will differentiate more advanced lean adopters in other settings. Ultimately, our findings suggest that although there is a common set of LMBs that positively co-vary with the level of adoption of lean operation practices (*H1*), specific subsets of those LMBs would probably characterize firms in different industries, geographical clusters and, eventually, each individual firm and its level of advancement in the adoption of lean operation practices. The identification of such subsets of behaviors and their alignment with the firm's strategy, culture, and external environment, is a key task for the top management of any company that wishes to seriously engage in the implementation of a lean system.

The second contribution is grounded on the idea that different sets of LMBs should be emphasized, nurtured, and developed, contingent upon the stage of adoption of lean operation practices as well as upon the number and type of lean operation practices implemented. From this standpoint, it is interesting to note that the lean literature discussed above almost unanimously considers the six behaviors we found as the best lean adopters' differentiators as among the most difficult to diffuse and sustain (Liker, 2004; Emiliani, 1998, 2003; Shook, 2008; Koenigsaecker, 2009; Rother, 2009; Liker and Convis, 2012; Mann, 2012). This is due to the fact that: they are the most ambiguous to interpret and the most difficult to sustain and practice (Marodin and Saurin, 2015); they require an adequate organizational infrastructure (Anand *et al.*, 2009); they require a long-lasting top management commitment (Boyer, 1996); and they are often associated with incorrect framing or misinterpretation by employees and the need to overcome their psychological resistance (Ortiz, 2012). For this reason, top management should clarify the expected behaviors, improve communication and decision-making processes, as well as guarantee access to organizational resources, remove obstacles (Scherrer-Rathje *et al.*, 2009; Martinez-Jurado and Moyano-Fuentes, 2012; Snee, 2010), and overcome cultural resistance (Bhasin, 2012).

More generally, this study represents a step in the direction of adopting a configurational approach to lean systems that acknowledges their social complexity and pushes toward a conceptualization that goes beyond the traditional notion of lean as a system of operations management practices (Azadegan *et al.*, 2013). More specifically, it integrates the idea of lean as a system of operations management practices (Shah and Ward, 2003) with the emerging concept of lean leadership and LMBs (Seddon, 2005; Emiliani, 2008; Mann, 2012; Liker and Convis, 2012; Van Dun *et al.*, 2017; Van Dun and Wilderom, 2016). This broader conceptualization will take into account a wider set of situations and better explain why lean programs may succeed or fail (Secchi and Camuffo, 2016).

Summarizing, the study offers four key contributions. First, it identifies, on the basis of a comprehensive literature review, a repertoire of management behaviors that in principle should support lean implementations and complement the adoption of lean tools and practices. Second, it provides a way to operationalize these management behaviors, and also provides a specific and rigorous method to detect them as well as a clear metric to evaluate their presence and intensity. Third, it offers the first empirical validation of this repertoire of behaviors showing that the higher their presence, the higher the level of adoption of lean operation practices. Fourth, it suggests, using a specific research setting as an example, that different subsets of LMBs might characterize a more advanced adoption of lean operation practices contingent upon the external context, the firm's strategy, culture and size, and the stage of implementation of the lean system.

The managerial implications of this study are straightforward and aligned with other recent studies (Scherrer-Rathje *et al.*, 2009; Hines *et al.*, 2011). First, it confirms that firms should avoid undertaking the adoption of systems of lean operation practices without adequately changing management behaviors. Excessive emphasis on lean tools often leads to the implicit, wrong idea that lean operation practices can be adopted without questioning the way in which managers (top managers included) behave, and that performance improvements will come from the adoption of lean operation practices, independently of the way in which managers lead, and of the social and psychological impact of their decisions and actions.

Second, focusing on management behaviors in lean environments serves to "bring people issues back into operations management" and provides an interface among organizational design, management control, and human resource management. Indeed, identifying, developing, and nurturing the appropriate management behaviors may represent a way to support the implementation of the lean operation practices and prevent their potential negative impact on workers' commitment – especially during the initial stage of adoption – which may generate worker resistance (Angelis *et al.*, 2011). Similarly, the development of appropriate management behaviors may prevent the often-cited difficulties in sustaining lean efforts over time (Marodin and Saurin, 2015).

7. Limitations and future research directions

This study is characterized by some limitations that future research will have to overcome.

First, our findings have clear boundary conditions that are defined by the characteristics of the context in which the study was conducted. Other multiple, cross-industry and cross-country studies will be necessary to validate a set of LMBs supporting the adoption of lean operation practices (Moyano-Fuentes and Sacristán-Díaz, 2012).

Second, the repertoire of LMBs that we propose should be considered as a starting point, to be refined and complemented. The definition and articulation of LMBs offered in this study should be sharpened and fine-tuned, more behaviors could be included, and the behavioral indicators could be changed, enriched, or better specified.

Third, as this study remains correlational and makes no causal inference, future studies should adopt more sophisticated identification and empirical strategies to estimate the

effects of LMBs on the level of adoption of lean operation practices. While this study represents only a first step and does not seek to determine causal relationships among the degree of adoption of LMBs and the degree of adoption of lean operation practices, such a causal relationship might be investigated by future studies with different research designs.

Fourth, longitudinal studies following a change in the level of adoption of LMBs and lean operation practices over time would make it possible to establish what really drives strategic heterogeneity and cross-firm differences with regard to lean implementation outcomes, as well as variation in cross-firm performance.

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References

Adler, P.S. (1993), "Time-and-motion regained", *Harvard Business Review*, Vol. 71 No. 1, pp. 97-108.

Anand, G., Ward, P., Tatikonda, M. and Schilling, D. (2009), "Dynamic capabilities through continuous improvement infrastructure", *Journal of Operations Management*, Vol. 27 No. 6, pp. 444-461.

Angelis, J., Conti, R., Cooper, C. and Gill, C. (2011), "Building a high-commitment lean culture", *Journal of Manufacturing Technology Management*, Vol. 22 No. 5, pp. 569-586.

Azadegan, A., Patel, P.C., Zangoueinezhad, A. and Linderman, K. (2013), "The effect of environmental complexity and environmental dynamism on lean practices", *Journal of Operations Management*, Vol. 31 No. 4, pp. 193-212.

Bass, B.M. and Avolio, B.J. (Eds) (1994), *Improving Organizational Effectiveness through Transformational Leadership*, Sage Publications, Thousand Oaks, CA.

Bateman, N. (2005), "Sustainability: the elusive element of process improvement", *International Journal of Operations and Production Management*, Vol. 25 No. 3, pp. 261-276.

Beauvallet, G. and Houy, T. (2010), "Research on HRM and lean management: a literature survey", *International Journal of Human Resources Development and Management*, Vol. 10 No. 1, pp. 14-33.

Bendoly, E., Donohue, K. and Schultz, K.L. (2006), "Behavior in operations management: assessing recent findings and revisiting old assumptions", *Journal of Operations Management*, Vol. 24 No. 6, pp. 737-752.

Bendoly, E., Croson, R., Goncalves, P. and Schultz, K. (2010), "Bodies of knowledge for research in behavioral operations", *Production and Operations Management*, Vol. 19 No. 4, pp. 434-452.

Bhasin, S. (2011), "Measuring the leanness of an organization", *International Journal of Lean Six Sigma*, Vol. 2 No. 1, pp. 55-74.

Bhasin, S. (2012), "Prominent obstacles to lean", *International Journal of Productivity and Performance Management*, Vol. 61 No. 4, pp. 403-425.

Bhasin, S. and Burcher, P. (2006), "Lean viewed as a philosophy", *Journal of Manufacturing Technology Management*, Vol. 17 No. 1, pp. 56-72.

Bicheno, J. and Holweg, M. (2009), *The Lean Toolbox: The Essential Guide to Lean Transformation*, PICSIE Books, Buckingham.

Boje, D.M. (1991), "The storytelling organization: a study of story performance in an office supply firm", *Administrative Science Quarterly*, Vol. 36 No. 1, pp. 106-126.

Boyatzis, R. (1998), *Transforming Qualitative Information*, Sage Publications, Thousand Oaks, CA.

Boyer, K.K. (1996), "An assessment of managerial commitment to lean production", *International Journal of Operations and Production Management*, Vol. 16 No. 9, pp. 48-59.

Byrne, A. (2012), *The Lean Turnaround: How Business Leaders Use Lean Principles to Create Value and Transform their Company*, McGraw Hill Professional, New York, NY.

Camacho-Minano, M.D.M., Moyano-Fuentes, J. and Sacristan-Diaz, M. (2013), "What can we learn from the evolution of research on lean management assessment?", *International Journal of Production Research*, Vol. 51 No. 4, pp. 1098-1116.

Campion, M.A., Fink, A.A., Ruggeberg, B.J., Carr, L., Phillips, G.M. and Odman, R.B. (2011), "Doing competencies well: best practices in competency modeling", *Personnel Psychology*, Vol. 64 No. 1, pp. 225-262.

Chell, E. (2004), "Critical incident technique", in Cassell, C. and Symon, G. (Eds), *Essential Guide to Qualitative Methods in Organizational Research*, Sage Publications, Thousand Oaks, CA, pp. 45-62.

Collins, J. (2001), "Level 5 leadership: the triumph of humility and fierce resolve", *Harvard Business Review*, Vol. 79 No. 1, pp. 67-76.

De Menezes, L.M., Wood, S. and Gelade, G. (2010), "The integration of human resource and operation management practices and its link with performance: a longitudinal latent class study", *Journal of Operations Management*, Vol. 28 No. 6, pp. 455-471.

De Treville, S. and Antonakis, J. (2006), "Could lean production job design be intrinsically motivating? Contextual, configurational, and levels-of-analysis issues", *Journal of Operations Management*, Vol. 24 No. 2, pp. 99-123.

Deming, E.W. (1986), *Out of the Crisis: Quality, Productivity and Competitive Position*, Cambridge University Press, Cambridge.

Dibia, I., Nath Dhakal, H. and Onuh, S. (2014), "Lean 'leadership people process outcome' (LPPO) implementation model", *Journal of Manufacturing Technology Management*, Vol. 25 No. 5, pp. 694-711.

Emiliani, M.L. (1998), "Lean behaviors", *Management Decision*, Vol. 36 No. 9, pp. 615-631.

Emiliani, M.L. (2003), "Linking leaders' beliefs to their behaviors and competencies", *Management Decision*, Vol. 41 No. 9, pp. 893-910.

Emiliani, M.L. (2008), *Practical Lean Leadership: A Strategic Leadership Guide for Executives*, The CLBM, LLC, Wethersfield, CT.

Fine, D., Hansen, M.A. and Roggenhofer, S. (2008), "From lean to lasting: making operational improvements stick", *McKinsey Quarterly*, Vol. 1 No. 11, pp. 38-55.

Flanagan, J.C. (1954), "The critical incident technique", *Psychological Bulletin*, Vol. 51 No. 4, pp. 327-335.

Found, P.A. and Harvey, R. (2006), "The role of leaders in the initiation and implementation of manufacturing process change", *The International Journal of Knowledge, Culture and Change Management*, Vol. 6 No. 8, pp. 35-46.

Fujimoto, T. (1999), *The Evolution of a Manufacturing System At Toyota*, Oxford University Press, New York, NY.

Gino, F. and Pisano, G. (2008), "Toward a theory of behavioral operations", *Manufacturing and Service Operations Management*, Vol. 10 No. 4, pp. 676-691.

Goleman, D., Boyatzis, R. and McKee, A. (2001), "Primal leadership: the hidden driver of great performance", *Harvard Business Review*, Vol. 79 No. 11, pp. 42-53.

Greenleaf, R.K. (2002), *Servant Leadership: A Journey Into the Nature of Legitimate Power and Greatness*, Paulist Press, Mahwah, NJ.

Hines, P., Holweg, M. and Rich, N. (2004), "Learning to evolve: a review of contemporary lean thinking", *International Journal of Operations and Production Management*, Vol. 24 No. 10, pp. 994-1011.

Hines, P., Found, P., Griffiths, G. and Harrison, R. (2011), *Staying Lean: Thriving, Not Just Surviving*, CRC Productivity Press, New York, NY.

Holweg, M. (2007), "The genealogy of lean production", *Journal of Operations Management*, Vol. 25 No. 2, pp. 420-437.

Hopp, J.H. and Spearman, M.L. (2004), "To pull or not to pull: what is the question?", *Manufacturing and Service Operations Management*, Vol. 6 No. 2, pp. 133-148.

Jackson, T.L. (2006), *Hoshin Kanri for the Lean Enterprise: Developing Competitive Capabilities and Managing Profit*, Productivity Press, New York, NY.

Koenigsaecker, G. (2009), *Leading the Lean Enterprise Transformation*, Productivity Press, New York, NY.

Lander, E. and Liker, J.K. (2007), "The Toyota production system and art: making highly customized and creative products the Toyota way", *International Journal of Production Research*, Vol. 45 No. 16, pp. 3681-3698.

Lewis, M.A. (2000), "Lean production and sustainable competitive advantage", *International Journal of Operations and Production Management*, Vol. 20 No. 8, pp. 959-978.

Liker, J.K. (2004), *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*, McGraw-Hill, New York, NY.

Liker, J.K. and Ballé, M. (2013), "Lean managers must be teachers", *Journal of Enterprise Transformation*, Vol. 3 No. 1, pp. 16-32.

Liker, J.K. and Convis, G.R. (2012), *The Toyota Way to Lean Leadership: Achieving and Sustaining Excellence through Leadership Development*, McGraw-Hill, New York, NY.

Liker, J.K. and Franz, J.K. (2011), *The Toyota Way to Continuous Improvement*, McGraw-Hill, New York, NY.

Liker, J.K. and Hoseus, M. (2008), *Toyota Culture: The Heart and Soul of the Toyota Way*, McGraw-Hill, New York, NY.

Liker, J.K. and Meier, D. (2007), *Toyota Talent*, McGraw-Hill, New York, NY.

Loch, C.H. and Wu, Y. (2007), *Behavioral Operations Management*, Now Publishers, Hanover.

Lucey, J., Bateman, N. and Hines, P. (2005), "Why major lean transitions have not been sustained", *Management Services*, Vol. 49 No. 2, pp. 9-13.

McClelland, D.C. (1998), "Identifying competencies with behavioral event interviews", *Psychological Science*, Vol. 9 No. 5, pp. 331-339.

MacDuffie, J.P. (1995), "Human resource bundles and manufacturing performance: organizational logic and flexible production systems in the world auto industry", *Industrial and Labor Relations Review*, Vol. 48 No. 2, pp. 196-218.

Mann, D. (2012), *Creating A Lean Culture: Tools to Sustain Lean Conversions*, CRC Press, New York, NY.

Marodin, G.A. and Saurin, T.A. (2015), "Managing barriers to lean production implementation: context matters", *International Journal of Production Research*, Vol. 53 No. 13, pp. 3947-3962.

Martinez-Jurado, P.J. and Moyano-Fuentes, J. (2012), "Key determinants of lean production adoption: evidence from the aerospace sector", *Production Planning & Control*, Vol. 25 No. 4, pp. 332-345.

Moyano-Fuentes, J. and Sacristán-Díaz, M. (2012), "Learning on lean: a review of thinking and research", *International Journal of Operations and Production Management*, Vol. 32 No. 5, pp. 551-582.

Nonaka, I. and Takeuchi, H. (1995), *The Knowledge-Creating Company*, Oxford University Press, New York, NY.

Ohno, T. (1988), *Toyota Production System: Beyond Large Scale Production*, Productivity Press, Cambridge.

Ortiz, C.A. (2012), *The Psychology of Lean Improvements: Why Organizations Must Overcome Resistance and Change the Culture*, CRC Press, Boca Raton, FL.

Pfeffer, J. and Sutton, R.I. (2000), *The Knowing-Doing Gap: How Smart Companies Turn Knowledge Into Action*, Harvard Business School Press, Boston, MA.

Pfeffer, J. and Sutton, R.I. (2006), *Hard Facts, Dangerous Half-Truths and Total Nonsense: Profiting from Evidence-Based Management*, Harvard Business School Press, Boston, MA.

Podsakoff, P.M., Mackenzie, S.M., Podsakoff, N.P. and Lee, J. (2003), "The mismeasure of man(agement) and its implications for leadership research", *Leadership Quarterly*, Vol. 14 No. 6, pp. 615-656.

Poksinska, B., Swartling, D. and Drotz, E. (2013), "The daily work of Lean leaders – lessons from manufacturing and healthcare", *Total Quality Management and Business Excellence*, Vol. 24 Nos 7-8, pp. 886-898.

Rother, M. (2009), *Toyota Kata: Managing People for Improvement, Adaptiveness and Superior Results*, McGraw Hill, New York, NY.

Safayeni, F., Purdy, L., Van Engelen, R. and Pal, S. (1991), "Difficulties of just-in-time implementation: a classification scheme", *International Journal of Operations and Production Management*, Vol. 11 No. 7, pp. 27-36.

Saurin, T.A., Marodin, G.A. and Ribeiro, J.L.D. (2011), "A framework for assessing the use of lean production practices in manufacturing cells", *International Journal of Production Research*, Vol. 49 No. 11, pp. 3211-3230.

Scherrer-Rathje, M., Boyle, T.A. and Deflorin, P. (2009), "Lean, take two! Reflections from the second attempt at lean implementation", *Business Horizons*, Vol. 52 No. 1, pp. 79-88.

Secchi, R. and Camuffo, A. (2016), "Rolling out lean production systems: a knowledge-based perspective", *International Journal of Operations & Production Management*, Vol. 36 No. 1, pp. 61-85.

Seddon, J. (2005), *Freedom from Command & Control. Rethinking Management for Lean Service*, Productivity Press, New York, NY.

Shah, R. and Ward, P.T. (2003), "Lean manufacturing: context, practice bundles, and performance", *Journal of Operations Management*, Vol. 21 No. 2, pp. 129-150.

Shah, R. and Ward, P.T. (2007), "Defining and developing measures of lean production", *Journal of Operations Management*, Vol. 25 No. 4, pp. 785-805.

Shippmann, J.S., Ash, R.A., Battista, M.A., Carr, L., Eyde, L.D., Hesketh, B., Kehoe, J., Pearlman, K., Prien, E.P. and Sanchez, J.I. (2000), "The practice of competency modelling", *Personnel Psychology*, Vol. 53 No. 3, pp. 703-740.

Shook, J. (2008), *Managing to Learn: Using the A3 Management Process to Solve Problems, Gain Agreement, Mentor, and Lead*, The Lean Enterprise Institute, Cambridge.

Snee, R.D. (2010), "Lean six sigma – getting better all the time", *International Journal of Lean Six Sigma*, Vol. 1 No. 1, pp. 9-29.

Soriano-Meier, H. and Forrester, P.L. (2002), "A model for evaluating the degree of leanness of manufacturing firms", *Integrated Manufacturing Systems*, Vol. 13 No. 2, pp. 104-109.

Spear, S. (2004), "Learning to lead at Toyota", *Harvard Business Review*, May, pp. 78-86.

Spear, S. and Bowen, H.K. (1999), "Decoding the DNA of the Toyota production system", *Harvard Business Review*, Vol. 77 No. 9, pp. 97-106.

Stone, K.B. (2012), "Four decades of lean: a systematic literature review", *International Journal of Lean Six Sigma*, Vol. 3 No. 2, pp. 112-132.

Van Dun, D.H. and Wilderom, C.P.M. (2016), "Lean-team effectiveness through leader values and members' informing", *International Journal of Operations & Production Management*, Vol. 36 No. 11, pp. 1530-1550.

Van Dun, D.H., Hicks, J.N. and Wilderom, C.P.M. (2017), "Values and behaviors of effective lean managers: mixed-methods exploratory research", *European Management Journal*, Vol. 35 No. 2, pp. 174-186.

Womack, J.P. (2011), *Gemba Walks*, Lean Enterprise Institute, Cambridge.

Womack, J.P. and Jones, D.T. (2005), *Lean Solutions: How Companies and Customers can Create Value and Wealth Together*, The Free Press, New York, NY.

Womack, J.P., Jones, D.T. and Roos, D. (1990), *The Machine that Changed the World*, MacMillan Press, New York, NY.

Wong, W.P., Ignatius, J. and Soh, K.L. (2012), "What is the leanness level of your organisation in lean transformation implementation? An integrated lean index using ANP approach", *Production Planning and Control*, Vol. 25 No. 4, pp. 273-287.

Further reading

Adler, P.S. and Borys, B. (1996), "Two types of bureaucracy: enabling and coercive", *Administrative Science Quarterly*, Vol. 41 No. 1, pp. 61-89.

Glenday, I. and Sather, R.L. (2013), *Lean RFS (Repetitive Flexible Supply): Putting the Pieces Together*, Productivity Press, Boca Raton, FL.

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