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Establishing the interplay between lean operating and continuous improvement routines: a process view

Wilfred H. Knol
Institute for Management Research, Radboud University, Nijmegen, The Netherlands and
Academy Engineering and Automotive, HAN University of Applied Sciences, Arnhem, The Netherlands
Kristina Lauche and Roel L.J. Schouteten
Institute for Management Research, Radboud University, Nijmegen, The Netherlands, and
Jannes Slomp
Academy Engineering and Automotive, HAN University of Applied Sciences, Arnhem, The Netherlands

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Abstract

Purpose – Building on the routine dynamics literature, this paper aims to expand our philosophical, practical and infrastructural understanding of implementing lean production. The authors provide a process view on the interplay between lean operating routines and continuous improvement (CI) routines and the roles of different actors in initiating and establishing these routines.

Design/methodology/approach – Using data from interviews, observations and document analysis, retrospective comparative analyses of three embedded case studies on lean implementations provide a process understanding of enacting and patterning lean operating and CI routines in manufacturing SMEs.

Findings – Incorporating the "who" and "how" next to the "what" of practices and routines helps explain that rather than being implemented in isolation or even in conjunction with each other, sustainable lean practices and routines come about through team leader and employee enactment of the CI practices and routines. Neglecting these patterns aligned with unsustainable implementations.

Research limitations/implications – The proposed process model provides a valuable way to integrate variance and process streams of literature to better understand lean production implementations.

Practical implications – The process model helps manufacturing managers, policy makers, consultants and educators to reconsider their approach to implementing lean production or teaching how to do so.

Originality/value – Nuancing the existing lean implementation literature, the proposed process model shows that CI routines do not stem from implementing lean operating routines. Rather, the model highlights the importance of active engagement of actors at multiple organizational levels and strong connections between and across levels to change routines and work practices for implementing lean production.

Keywords Lean production, Organizational learning, Continuous improvement, Organizational routines, Process research, Routine dynamics

Paper type Research paper

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Introduction

This paper expands our understanding of how lean production can be implemented by changing existing and establishing new organizational routines. Research has comprehensively shown that lean production requires an interplay between lean operations and continuous improvement (CI) (Cua *et al.*, 2001; Flynn *et al.*, 1995a; Imai, 1986; Karlsson and Åhlström, 1996; Liker, 2004; Ōno, 1988; Shah and Ward, 2003, 2007; Sugimori *et al.*, 1977; Womack *et al.*, 1991). It is less clear how this interplay unfolds over time. Some suggest that lean production can be implemented starting with management or expert-led improvements, involving team leaders and employees later on (Liker, 2004; Womack and Jones, 2003). This approach is reflected in maturity models on lean production and CI depicting the learning organization as the final ideal stage (Bessant and Francis, 1999; Hines *et al.*, 2004). More recently, Galeazzo *et al.* (2021) draw on cross-sectional data to suggest that a top-down approach is preferable when CI is low, whereas a bottom-up approach is helpful for more advanced CI practitioners. This study takes a process view to revisit how lean operations and CI unfold over time and examine how different actors contribute to this process.

To understand how lean production implementations unfold, this paper draws on the routine dynamics literature (Feldman and Pentland, 2003). Routine dynamics literature distinguishes between the enacting and the patterning of routines (Feldman, 2016). Enacting relates to how a routine is performed, while patterning relates to the shared understanding or "ostensive" aspect of that routine (Feldman and Pentland, 2003). This paper draws on enacting and patterning and their interplay *within* organizational routines to show how actors move *towards* and *between* lean operating and CI routines. Understanding how lean operating and CI routines co-evolve is essential for understanding when and why lean production implementations succeed or fail, and how the implementation process can be managed. This paper addresses the question: *How do lean operating and continuous improvement routines develop during a lean production implementation?* To answer this question, this paper reports on an abductive analysis of three series of interventions in three manufacturing SMEs. This analysis helped to develop a process model to better understand how actors move towards and between enacting and patterning lean operating and CI routines.

To take a dynamic view on lean production implementations, a processual understanding of organizations is required (Van De Ven and Poole, 2005). The majority of studies on lean production implementations have (implicitly) adopted a variance view, meaning they address the effect of predictors on outcomes, rather than the transformation process between them. A process view aims to open this black box to explain how the relationships between the studied constructs come about and to understand the organizational transition (Sinha and Van De Ven, 2005). The difference can be compared to a noun (variance) and a verb (process) or a picture (cross-sectional) and a film (longitudinal): a picture can capture a static object, only a film can capture how it is moving. In organization theory, a process view differs from how the term "process" is commonly used in operations management (e.g. Holweg *et al.*, 2018) and in lean production regarding process mapping tools (e.g. Rother and Shook, 1999). In organization theory, a process view considers any organizational activity as an ongoing accomplishment (Feldman, 2000). As such, a process view helps to explain how practices and routines come about and can be shaped to create a collective understanding of lean production.

The findings have important implications for research and practice. First, this paper proposes a process model that explains, on a fundamental level, how the interplay between patterning and enacting lean operating and CI routines unfolds over time. Second, this paper shows how different actors contribute to establishing new routines, providing a more accurate picture of how infrastructural or critical success factors (CSFs) such as top management support and leadership actually play out in implementation processes. Third, the process model sheds new light on our understanding of how to implement lean production, specifically regarding maturity models and the implicit sequencing of lean principles.

The remainder of this paper first introduces the concepts of enacting and patterning lean operating and CI routines in implementing lean production. The empirical part consists of a comparative analysis of a series of lean production interventions in three manufacturing SMEs. The findings illustrate how enacting and patterning routines interplay over time and the role that different actors play in this process. The paper ends by explaining how researchers and practitioners might use this approach to better understand and guide lean production implementations.

Implementing lean production: organizational routines

This section conceptualizes how the enacting and patterning of lean operating and CI routines might interact.

Lean operating routines and continuous improvement routines

Organizations act and change based on certain routines (Nelson and Winter, 1982). An organizational routine is defined as "*a repetitive, recognizable pattern of interdependent actions, involving multiple actors*" (Feldman and Pentland, 2003, p. 96). Nelson and Winter (1982) differentiate between routines in day-to-day operations and routines for improving those operations. Routines in day-to-day operations are called operating routines. They relate to what an organization does, given its customer requirements, capabilities, stock, procedures, equipment, etc. Operating routines follow a sequence of steps, with each step triggering another, based on tacit knowledge and more or less automatic choices. These operating routines are key to ensuring the short-term survival of the organization. Routines for improvement are called search or improvement routines and focus specifically on developing operations (Nelson and Winter, 1982). Improvement routines are part of an organization's dynamic capabilities to do different or new things (Anand *et al.*, 2009; Peng *et al.*, 2008). These routines can be developed through a recursive pattern of production, learning or better understanding, and reproduction of either actual operations or actual improvements (Zollo and Winter, 2002).

In the context of lean production, lean operating routines relate to principles such as flow and pull (Womack and Jones, 2003), meta-routines such as JIT (Sugimori *et al.*, 1977) and supplier integration (Lamming, 1996) and practices such as the use of Kanban, squares or containers for production control. CI routines relate to principles such as perfection (Womack and Jones, 2003), meta-routines such as TQM (Hackman and Wageman, 1995) and CI (Bessant and Caffyn, 1997) and practices such as the initiation and performance of Kaizen activities. Some principles such as value (Womack and Jones, 2003), meta-routines such as TPM (Nakajima, 1988) or concepts such as employee involvement seem to relate both to lean operations and CI. In line with the above definition, this study considers lean operating and CI routines to be recognizable patterns of interdependent actions, involving multiple actors.

The shared enacting and patterning of routines

Feldman and Pentland (2003) distinguish between the performative and the ostensive aspect of routines. The performative aspect refers to enacting routines, the "*specific actions, [done] by specific people, in specific places and times . . . it is the routine in practice*" (Feldman and Pentland, 2003, p. 101). The ostensive aspect is considered to be "*the ideal or schematic form of the routine . . . it is the abstract, generalised idea of the routine or the idea in principle*" (Feldman and Pentland, 2003, p. 101). This ideal form always exists inside and across actors; it is their shared understanding of the routine. The ostensive aspect has more recently been conceptualized as patterning to indicate that it is not merely a mental construct but also embodied (Feldman, 2016). Feldman and Pentland (2003) view the enacting and patterning of a routine not as two opposing phenomena but as a duality, influencing each other continuously. Patterning is both the input and the outcome of enacting (Feldman and Pentland, 2003).

To better understand the difference between enacting and patterning, think of, for example, a professional soccer team. For their entire life, the players are individually and collectively training to play soccer; to pass, dribble, shoot, etc. Playing soccer has become their second nature. It is ingrained in their mind and also in their body, their muscles, nervous systems, responsiveness, etc. Collectively, they are the soccer team even when they are not playing at all. This shared embodiment of the routine is referred to as patterning, while the actual performance during a game is called enacting. This concept of routines builds on Giddens' (1984) idea of the duality of structure and agency: the schematic understanding of the routine guides the enacting, while the enacting simultaneously constitutes the patterning.

In lean operations, an example of enacting is employees using a pull system, i.e. initiating an order only if triggered by a request downstream. An example of CI would be employees mapping their current situation, looking for ways to improve their operations. Pattering in lean operations can be seen in employees' shared understanding of concepts such as "pull limit". An example in CI is employees' shared understanding of how a current state could be mapped. The routine dynamics literature emphasizes that enacting and patterning always need to be considered in tandem.

Artefacts and organizational routines

Organizational routines both influence and are influenced by artefacts (D'Adderio, 2008; Pentland and Feldman, 2008). Artefacts are defined as structures external to actors, either physical (e.g. machines and products) or intangible (e.g. software and standards), and can range from single documents to systems of interdependent artefacts (Cacciatori, 2012; Hutchins, 1995). Artefacts can be classified into a three-level hierarchy: (1) primary artefacts that are used to do work (e.g. machinery and tools), (2) secondary artefacts that facilitate work (e.g. production orders and standard operating procedures), and (3) tertiary artefacts that form the infrastructure (e.g. buildings, rooms, furniture, ICT and documents) (Nicolini *et al.*, 2012). Cacciatori (2012) explains that routines are developed using systems of artefacts (e.g. occupation-specific artefacts such as tools and techniques linked to more generic artefacts such as planning systems), stressing the importance of an integrated approach.

In lean operations, examples of physical artefacts are the Kanban cards used to limit work-in-progress. Examples of intangible artefacts are formulas and techniques such as takt time and Little's Law that help to determine the number of Kanban cards in the system. In CI, examples of physical artefacts are performance boards and A3 problem-solving reports to identify and address improvements. Examples of intangible artefacts are tools such as plan-do-study-act and 5-whys (Bicheno and Holweg, 2016) that help to analyse and improve identified issues. The routine dynamics literature emphasizes that artefacts must be implemented not only in line with each other but also in line with the enacting and patterning of organizational routines.

Moving from prior routines to lean operating routines

Neither organizational routines nor artefacts are static: they can be modified through ongoing enactment (Feldman and Pentland, 2003; Giddens, 1984) and deliberate problem-solving (Adler *et al.*, 1999; Hackman and Wageman, 1995). Ongoing enactment may lead to a continuous incremental change of routines (Feldman and Pentland, 2003; Giddens, 1984). This change occurs when employees adjust routines to the circumstances at hand and to their own understanding (Rerup and Feldman, 2011). Deliberate problem-solving can also lead to changes in routines. CI activities are an example of such deliberate change: employees experiment and alter the underlying lean operating routines. Through trial-and-error learning and reflecting on what works and why, they develop a new shared understanding of what could be done (Feldman and Pentland, 2003; Giddens, 1984; Rerup and Feldman, 2011). Thus, the interaction between enacting and understanding lean operating routines and CI routines provides a continuous opportunity for learning and improvement. This shared learning is further stimulated by artefacts (Aoki, 2020). It is this employee reflexivity that, over time, contributes to organizational learning and actual improvements (Argote and Miron-Spektor, 2011).

This paper conceptualizes implementing lean production as developing the interplay between enacting and patterning lean operating and CI routines: (1) Enacting lean operating routines and enacting CI routines mutually influence each other, and they jointly shape how both types of routines are patterned. (2) Patterning lean operating routines and patterning CI routines also mutually influence each other and both patterns shape how these routines are enacted. (3) Artefacts related to lean operations and CI influence each other and jointly influence and are influenced by the enacting and patterning of lean operating and CI routines, respectively. As employees develop lean operating and CI routines again and again, operational performance increases, and at the same time, the patterning of what lean operating and CI routines could achieve improves, thus leading to employee learning. Over time, this continual interplay helps to implement lean production in a sustainable way.

Understanding the process of changing routines and work design

Patterning routines could be seen in the context of work design. Work design contains the structural rules, norms and understandings of how to do the work and an understanding of the responsibilities of actors at different organizational levels. Sinha and Van De Ven (2005) propose to examine work design from a complexity perspective that traces the sequence of events that unfold over time in a changing work system configuration. The more static concepts of contingency and configuration theory have proposed ingredients for performance that are either present or absent, such as CSFs. Instead, a processual approach sees work design as emerging and pays more attention to the transition from one work design to another. In the case of lean production, the literature has identified top management support and leadership as CSFs for implementing lean production (Achanga *et al.*, 2006; Saraph *et al.*, 1989; Sila and Ebrahimpour, 2003), yet this literature provides limited insight into when and how managers affect the transition of work design. More practice-oriented research gives a detailed account of CI routines (improvement kata) and how these are developed (coaching kata) at Toyota (Rother, 2010), yet it is less clear how different actors contribute to this transition to new CI routines. In this study, the implementation of lean operating and CI routines is analysed as a process of transiting to new work design arrangements and specifically the role of different actors is investigated.

Methods

Retrospective comparative analysis

Retrospective case studies were chosen because they allow for investigating the long-term effect of what actors did and thus provide insight into how organizations develop over time (Pettigrew, 1990). Compared to longitudinal case studies, they allow for examining this effect in cases for which the outcome is known. Given the complexity of the research question, multiple cases were needed (Eisenhardt and Graebner, 2007; Meredith, 1998). For each case, several interventions were investigated.

Case selection

In line with Yin (2013), a quantitative inquiry of candidate case characteristics was conducted to select contrasting cases that (un)successfully implement lean production.

To select cases, hard lean practices and CSFs were used as indicators. Hard lean practices were chosen, as they are similar to lean operating routines (Bortolotti *et al.*, 2015) and a reliable indicator for lean production organizations. They were measured using Shah and Ward's (2007) questionnaire on lean practices. CSFs were chosen as these are not directly linked to hard lean practices – they are considered necessary but not sufficient for implementing lean production (Knol *et al.*, 2018). The presence of CSFs indicated the extent to which cases invested in implementing lean production. For CSFs, the questionnaire by Knol *et al.* (2018) was used. To select successful cases, we chose one (Case A) with the highest presence of hard lean practices, and one with much presence of lean practices and low presence of CSFs (Case B, see dotted red line in Figure 1). To contrast the successful lean production cases, an unsuccessful lean production case was also selected. To this end, a case was selected with much presence of CSFs but low levels of hard lean practices (Case C).

Dimensions of interest that were not used are operational performance, soft lean practices and CI routines. Operational performance matters to all organizations, yet in itself is only a partial indicator for lean production, as operational performance can also be achieved by non-lean producers. Soft lean practices indicate practices that are related to CSFs, such as "top management support" and "training employees", and to CI routines, such as "solving problems in small groups" and "striving to continuously improve products and processes" (Beraldin *et al.*, 2019; Bortolotti *et al.*, 2015). CI routines are different from hard lean practices, but their enactment ultimately results in lean production organizations, making hard lean practices and CSFs the most useful indicators to select successful and unsuccessful lean production cases.

To select cases that covered both dimensions, multiple respondents (6 on average, 251 in total) from 42 manufacturing SMEs were asked to fill in a self-assessment on their plant. Case A featured advanced lean practices (dashed circle), representing a successful case. Case B featured some lean practices combined with some CSFs (dotted circle), showing how lean practices can be relatively high without much presence of CSFs. These cases were

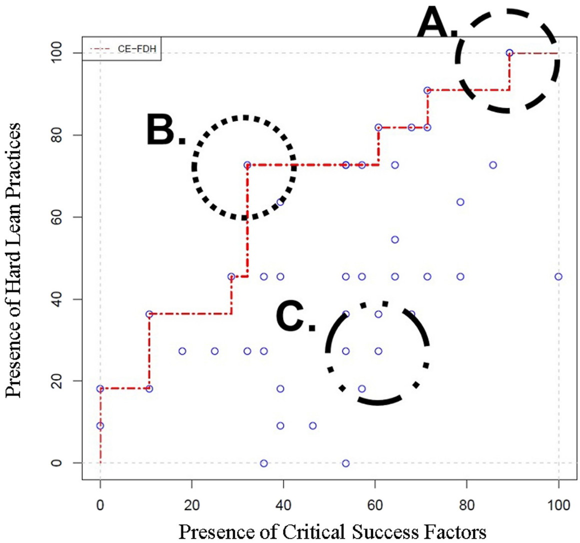


Figure 1.
Case selection: diverse cases (A. dashed and B. dotted circle) and polar type (C. solid-dotted circle)

supplemented with one extreme or polar case, Case C, which featured the presence of CSFs but little lean practice implementation (dashed-dotted circle). A summary of the three case characteristics is given in Table 1. Given this diverse set, these three cases were considered sufficient to explore the interplay between lean operating and CI routines to implement lean production (Eisenhardt, 1989; Stuart *et al.*, 2002).

Data collection

An embedded case study design was used to study improvements to both lean operating and CI routines (Yin, 2013). Data gathered were retrospective, lasting from the first lean initiatives to the current state of CI interventions. To limit recall bias and enhance accuracy (Eisenhardt and Graebner, 2007; Golden, 1992), the researchers focused on important recent and present activities. To limit informant bias, employees, team leaders, managers and CEOs from production and supporting departments were involved and data were collected using interviews, observations and archives (internal documents and websites) (Eisenhardt and Graebner, 2007; Jick, 1979).

Per case 10–11 interviews were conducted. Interviewees worked for their company between 1 and 36 year(s) with an average of 17 years. They were working with lean production between 3 and 17 years with an average of 9 years. Their understanding of lean production ranged from limited to good. And all of them had tenure (not temporal) allowing them to speak freely. They were selected due to their involvement in lean production interventions and from different hierarchical levels (CEO, manager, team leader and employees). We included employees as they also contributed to the lean production implementations. As insights evolved, interview questions developed from open (e.g. "What did you do to implement lean production?") to semi-structured (e.g. "How did you improve enactment of lean operating routines?" (see Appendix 1 – Interview guide). As data collection developed, a code book was also developed to maintain more focus (Fereday and Muir-Cochrane, 2006; Van Maanen, 1979). Interviews took between 28 and 85 min with an average of 53 min. They were recorded and transcribed, with transcripts ranging from 5 to 17 pages with an average of 10 pages. The transcripts were discussed with colleagues and fellow researchers afterwards to enhance data analysis and increase the reliability of the study results.

To limit common method bias, interviews were complemented with numerous observations and documents (Eisenhardt and Graebner, 2007). Observations took place while the first author was working at the case site for three to four days over the course of three to four weeks. Observations took place during semi-guided tours, work sessions such as stand-ups or project meetings, walk-arounds on the shop floor and informal talks in, for example, the canteen. Observations were especially conducted to verify interviewee experiences with the interplay between the enacting and patterning of lean operating and CI routines. For example, to identify interactions between the concepts, work was studied in the different cells, at stand-ups and during 8D improvement sessions in Case A, at the production machinery, at stand-ups and during A3 improvement sessions in Case B and at the workstations in Case C. Documents were used to establish the chronology of improvement interventions, build the timelines, guide the interviews and counteract any biases originating from the interviews. Documents were either policy documents, performance sheets, standard operating procedures, presentations or training materials. All findings were presented to and discussed with the case participants afterwards to increase understanding of the case and the quality of the data gathered (Call-Cummings, 2017; Jick, 1979).

Data analysis

Induction and deduction were combined into an abductive analysis of each case (Ketokivi and Choi, 2014). The process of lean production implementation was traced as follows.

Table 1.
Summary of the three case characteristics

Selection strategy	Case	Presence of lean practices	Presence of CSFs	Industry/ products	Strategy	Layout	Number of employees	Inter-viewees	Introduced lean operating structures	Introduced CI structures
Diverse cases	A	Advanced	Extensive	High-tech electronics	Product leader	Cells	250	11	Lines, cells, teams, 5S, standards vs specials, Kanban boards	Quality control, PDSA, 8D problem-solving reports, stand-ups
	B	Some	Some	Concrete paving materials	Product leader	Mass-production line	40	10	5S, total productive maintenance, just-in-time supply, customer integration	PDSA, single-minute exchange of die, A3 reports, stand-ups, X-matrix
Polar type	C	Few	Some	High-quality metal building materials	Customer intimacy	Functional	100	11	Pull, i.e. a train and Kanban, small lot sizes, standard operating procedures	-

We used the thematic coding technique to conduct within-case and cross-case analyses in an iterative fashion (Flick, 2009, pp. 318–323). As a first orientation and to map the chronology of each case, written narratives (see Section "Findings from the within-case analyses") and timelines (see Appendix 2 – Case timelines) were created for each case from the interviews (Miles *et al.*, 2013). These descriptions were continuously rechecked and modified during further interpretations of the cases. To increase validity, these were validated against the document analyses and reviewed by the respective Production Manager (Miles *et al.*, 2013). To reduce the effects of telescoping or recall bias (Beckett *et al.*, 2001), these timelines, in turn, helped to cross-check the sequence and details of events derived from different interviews per case. In general, the interviewees agreed largely in their account of events. If their accounts differed, the document analysis was used to arbitrate.

Next, a deepening analysis was conducted per case. This led to a focus on the themes enacting and patterning lean operating and CI routines. Open coding was done by the first author to identify first-order constructs. These constructs were organized in statement cards to better understand the themes in the data. What struck us was the importance of structure and agency during all lean production implementations. These concepts first led us to Giddens' structuration theory (Giddens, 1984) and subsequently to the routine dynamics literature (Feldman and Pentland, 2003). We started to analyse our data in terms of enacting and patterning lean operating and CI routines. The findings were frequently contrasted with the literature to build and periodically refine the code book (McCutcheon and Meredith, 1993), see Table 2. This led to ideas for the interplay, which acted as a framework for another round of comparing the empirical results of the case studies, helping to develop the interplay further (Yin, 2013).

Finally, the two diverse cases were juxtaposed with each other and with the polar case to cross-check how the interplay between enacting and pattering lean operating and CI routines evolved over time. This eventually led to an empirical process model. This process model underlay the comparative analysis of each of the three cases. Analysing what was similar or contrary to this broad empirical framework enabled theory building from the cases. The empirical process model was presented to and discussed with the interviewees in a final round (communicative validation (Call-Cummings, 2017; Jick, 1979)) to increase the quality of our interpretation.

Findings from the within-case analyses

Case A – advanced presence of lean practices

Case A started implementing lean production in 2004, when a new lean-minded Managing Director was appointed (see Appendix 2 – Case timelines, Figure A1 for an overview). In 2009, CI activities were started in two departments to improve their operations. First, lean games were played to improve employees' understanding of lean operating routines. Next, an external consultant guided two team leaders to involve employees in mapping current states, conducting root cause analyses, mapping future states, etc. with the aim to create a production line (system of artefacts). The approach focussed on involving employees: "*So do not say:* 'You must do this differently', *but just ask:* 'How could that mistake happen, how was that possible?' *Then slowly try to get things better, without throwing anyone under a bus.*" (Engineering Manager, Case A). These interventions improved employees' operating routines and as a result improved the quality, flow and lead time. Additionally, employees mentioned that the approach helped them to understand the importance of CI routines and related artefacts such as 8D problem-solving reports. When major successes were achieved, the team leader moved to other departments to repeat the CI efforts. The first two departments continued with their efforts.

Aspect	Action	Definition	Quotation
Developing ostensive aspects	Engaging employees to develop an understanding of the principles and ideas of operating and improvement routines	The importance of operating and improvement structures is sold to employees through lean games, internal or external excursions, training, performance management and/or involvement in improvement activities, and discussions	"When I asked [him] if he wanted to do the course and explained that he would also do two or three projects every year, he was very hesitant, he was very busy already. He saw it as extra work. . . . While I was talking, I tried to make it clear to him: "You are doing those projects already. Only now you get a tool to do it in a structured way, with a head and a tail, to efficiently manage your projects." Then he understood that he did not have to do anything extra but that his current work would be done in a more structured manner. Now he is almost done with his first project which is going very, very well!" – Improvement Manager, Case B
Improving performative aspects	Providing employees with what is necessary to improve operating and improvement routines	Employees are triggered and empowered to initiate and carry through improvement activities using measurement, tools and techniques and they are guided during the enactment of these improvement activities	Interviewer: "How do you get people to such a stage that they do it themselves without you looking at it?" Respondent: "I think they must experience it. . . . When you approach relatively simple problems, you can show them the kind of influence they have themselves, so that they can pick it up themselves easily." – Improvement Manager, Case A
Implementing related artefacts	Finding and organizing artefacts related to operating and improvement routines	Operating and improvement structures, objects, tools and systems are searched for, found and used to guide operating and improvement activities	"Here we came up with the train system. This is the pillar of our new method. . . . If we expand this with hand scanners and we ensure prioritisation through a funnel, where you throw everything in and then only one thing comes out, we are golden." – Engineering Manager, Case C

(*continued*)

Table 2.
Code book on interventions to implement lean production

Aspect	Action	Definition	Quotation
Managing through time	Maintaining feasible steps through time	Lead time of improvement projects is reduced by choosing manageable scopes, doing them sequentially and frequently following up on them. This enables employees to experience that their efforts lead to a better workplace, understand the reason for improvement, reduce resistance and increase motivation to participate and thus keep the momentum	"At that moment it brought a lot of resistance because the employees said, "We can set our own pace but now you are pushing us." Then there was a heated discussion, where I said, "You must set the pace, but we also have to take steps because right now we have been on the same level for months." . . . The agreement we made afterwards is that the Plant Manager goes to the shop floor every Wednesday afternoon to do his 5S round and to understand how best to facilitate them. . . . After we made that agreement, we saw it progress very quickly." – Improvement Manager, Case B

Table 2.

In 2011, a CI Manager was appointed. She aimed to integrate CI routines into the work routines of employees to help them understand the reasons for and functioning of lean operating routines. During our presence, we saw that she often engaged employees, explained CI and lean operating artefacts and coached them to conduct their own CI activities. "*You can guide people without having to prescribe the route they take. They have to make mistakes to learn why a 5-why is carried out in one way and not the other. The moment they run into something, you can send them in the right direction. The progress is much better and the effect too; people are more positive about it.*" (CI Manager, Case A).

In 2015, a new lean-minded Operational Director joined the company and started to implement 5S company-wide. 5S is a workplace organization method aimed at increasing productivity. All employees were trained to improve their understanding of 5S artefacts and then told to conduct weekly 5S actions. However, there was little follow-up on the initial training and no coaching to assist the employees in better understanding or enacting these weekly 5S routines. As a result, employees experienced the 5S method as forced and only for show. The approach resulted in bad reception and eventual abandonment.

The new Operational Director also changed the work design and introduced cells, making employees responsible for their own processes. "*Remove the functional in production and start thinking in cells. . . . So, I asked the teams which production cells they see. We have given them a guideline and told them,* 'You can build a cell in it' . . . *and they slowly grew into it.*" (Operational Director, Case A). From informal conversations with employees during our visits, we understood that continuously conducting cycles of improvements helped them to internalize their cell routines and implement related artefacts such as Kanban boards. The Quality Manager added: "*Every time you think you have solved something, you notice six other problems that also need to be addressed*". From multiple conversations, we also understood that continuous support in terms of coaching, time and resources strengthened the shared understanding and shared enacting of the new work design and the associated CI routines.

Case B – some presence of lean practices

Case B is one of four sites or plants of a manufacturing SME. In Case B, the initial improvements started with the arrival of a new Plant Manager in 2001 (see Appendix 2. Case timelines, Figure A2 for an overview). After years of local improvements, other managers became interested and attempted to implement 5S company-wide, including at Case B. However, like in Case A, there was little coaching about implementing 5S artefacts or developing 5S routines. From the interviews, we learned that this first implementation was experienced as forced and led to employee resistance, and only a few changes were sustained.

A new lean-minded Operational Director and CI Manager joined the company in 2013 and continuously engaged employees in CI activities, such as mapping current states, conducting root cause analyses, mapping future states, etc. They also introduced a focus on flow and introduced among others A3 reports to realize more structure in CI activities. Some employees were encouraged to take up lean Green Belt training but they told that because of their high workload they were not very enthusiastic at first. To overcome this resistance, the CI Manager repeatedly tried to engage them in conducting CI projects and explained the need (see the second quote in Table 2).

In 2017, management decided to implement 5S again, however not company-wide as previously, but team by team, in weekly cycles and with a focus on engaging in CI activities. The need for 5S was clearly explained upfront and during CI activities. However, employees still felt it was forced upon them. The CI Manager tried to mitigate this by engaging in dialogue (see the last quote in Table 2). He explained the need and encouraged them to conduct, for example, quicker product changeovers by using, for example, shadow boards. Weekly audits were introduced to sustain the achieved results. These audits were still being done during our visits. When the roll-out moved to the second team, they were already interested in 5S because of the first team's results. At the end of the study, both teams continued to enact and develop 5S routines as part of their standard practices.

By now, management considered the cycle of involving employees in CI routines to internalize lean operating routines and to implement related artefacts for subsequent improvement as crucial for implementing lean production. "*In the past, you often saw projects where people were not engaged. Then as soon as you were gone, they fell back again. If you engage them, it is more likely to succeed.*" (Quality Manager, Case B).

Case C – little presence of lean practices

Improvements at Case C started with the arrival of an Engineering Manager and an Aluminium Team Leader in 2007 (see Appendix 2. Case timelines, Figure A3 for an overview). They first used a lean game to involve the Production Manager and then played the game with the entire company. This helped to increase employees' understanding of lean operating routines. However, there was little follow-up; there were no attempts to stimulate employees to enact CI activities and there was no guidance regarding lean operating routines or artefacts. During several interviews, employees mentioned that the efforts of the two lean change agents were experienced as ineffective, expensive and pushy. The training raised awareness but did not succeed in getting everyone started.

In the Aluminium department, the team leader tried to implement 5S using training. From his explanation, we noticed that there was little engagement and coaching to stimulate employees to conduct CI activities, implement 5S artefacts or improve their 5S routines. Employees themselves indicated that 5S was not internalized. And a lack of evidence on the shop floor showed that this 5S implementation was not sustained. In 2013, a temporary lean team changed the order system to pull principles in an expert-driven manner. When they faced resistance, they staged a "*coup*":

> Then we figured out that the way we produce here must be done completely differently, it must be done with a "train system". We changed this through a coup. . . . We presented the idea to the MT and the team leaders and explained that this is how it will be done. . . . But what happened? I went to the Production Manager on Friday and asked if everything was prepared. "No", he said, "not yet". I said, "This is not what we agreed upon." He asked, "Can we talk about this with the rest of the team leaders?" We then gave everyone instructions. I went to the planner to ask if he was ready, but he was very busy and not prepared. I said, "There is no choice, we agreed upon this, we are going to do it!" Within four hours, we changed everything to the new system with a different planner. (Engineering Manager, Case C, authors' emphasis).

The team leader and planner had not enacted CI routines and they had not created a shared understanding of lean operating routines; they were left unprepared. The change in work design was still present during our visits, but it was not further developed, hence resulting in a one-off exercise. A second attempt to introduce improvements also showed little engagement and no attempts to stimulate team leaders and employees to conduct CI activities. Team leaders were instructed in writing to reduce their lead time by half. However, employees on the shop floor did not see the need and the initiative fell flat.

The interviewees explained that in a third attempt, external consultants were hired to conduct daily performance sessions for a year. These meetings required strict business cases and yielded some results. However, the frequency of these meetings declined over time until they ended completely. There were no CI routines or related artefacts to engage employees and, during our presence, there was no sign of coaching or templates such as 8D or A3 as in Case A and Case B, let alone cycles to further develop this entire process.

At the end of the study, improvements occurred only from time to time and involved only a small number of improvement experts. Their initiatives failed often due to a lack of time: "*I am engaged in engineering. I do not have time to do that anymore. . . . So, it is an extra job and we are busy, it falls back again*" (Engineering Manager, Case C).

Findings from the cross-case comparison

Moving from prior to improvement routines

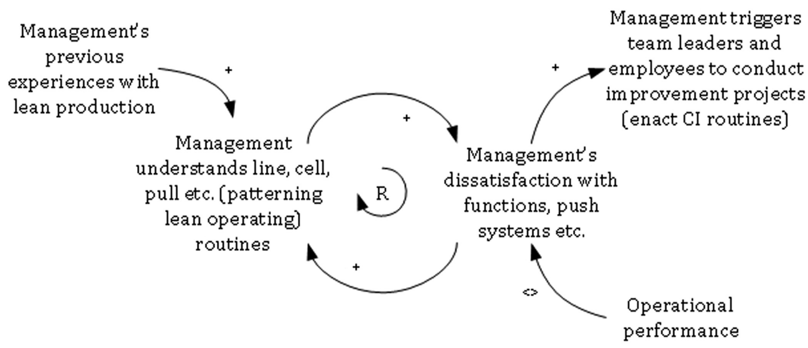
In all cases, the findings show that introducing lean operating routines clashed with the prior way of working. New managers, experienced with lean production from previous roles, challenged the shared understanding of existing operating routines such as functional layouts and push systems. In the two successful cases, A and B, several leaders (Directors, Managers and Team Leaders) played a key role in the implementation process. Rather than starting with management or expert-driven improvements for employees to learn from, in Cases A and B managers engaged and coached team leaders and employees in conducting improvement projects; triggering them to make current state maps, root cause analyses, future state maps, etc. This helped them to create a shared understanding of lean operating routines such as lines, cells and pull systems. To engage employees who did not want to participate in improvement activities, the CI Manager in Case B provides two excellent examples (importance of Green Belt and second attempt at 5S) of what to do: initiate a conversation, ask what bothers them, convince them otherwise and stimulate and facilitate them to try. Noticeably, operational performance only played a minor role in managers' motivation. This is illustrated in Figure 2; (top) managers break with prior non-lean operating routines and challenge team leaders and employees to conduct improvement projects.

Moving from improvement routines to lean operating routines

Enacting improvement routines to pattern lean operating routines and implement related artefacts. The cross-case analysis further explains the move from CI routines to lean operating routines. First, conducting improvement projects (mapping current states, conducting root cause analyses, mapping future states, etc.) helped to create a shared understanding of lean operating routines (lines, cells, pull systems, etc.). In the unsuccessful Case C, two leaders (Engineering Manager and Aluminium Team Leader) tried to trigger the interplay between lean operating and CI routines by engaging managers and employees in lean games. When they faced resistance, they tried to have team leaders and employees enact lean operating routines straight away by showcasing the potential benefits of using 5S and a pull system. Only when further improvements were unforthcoming, they tried to conduct improvement projects but they used consultants. Though some results were achieved, over time both approaches (enacting lean operating routines without enacting CI routines and enacting CI routines using consultants) resulted in neglect and regression to previous routines. In contrast, Cases A and B took a different approach; it was their upfront involvement of team leaders and employees in conducting improvement projects that helped to develop a shared understanding of lean operating routines. This is illustrated in Figure 3; conducting improvement activities helped team leaders and employees to create a shared understanding of their lean operating routines. The remainder of Figure 3 will be elaborated upon below.

Second, involving team leaders and employees in conducting improvement activities also helped to implement line, cell, pull, etc. artefacts. Using cycles of improvement activities, Case A successfully introduced lines, cells and cross-functional teams, and Case B successfully introduced 5S, total predictive maintenance and just-in-time deliveries. Lean operations-related artefacts subsequently helped enacting of lean operating routines to increase operational performance. When CI routines were not enacted by employees, implementations of lean operating artefacts were unsuccessful. All three cases tried to implement 5S structures in a predominantly top-down fashion. This was problematic and eventually failed in all cases. Only when Case B challenged employees to enact CI routines did employees discover the importance of 5S for operations, helping them to successfully implement 5S artefacts. This is illustrated in Figure 3; enacting CI routines also helped team leaders and employees implement lean operating artefacts.

Enacting lean operating routines to pattern improvement routines and implement related artefacts. Third, the case data indicate that team leader and employee enacted lean operating



Note(s): 'R' implies a reinforcing loop, '+' implies positive influence and '<>' implies little influence

Figure 2.
Process model on the move from prior to improvement routines

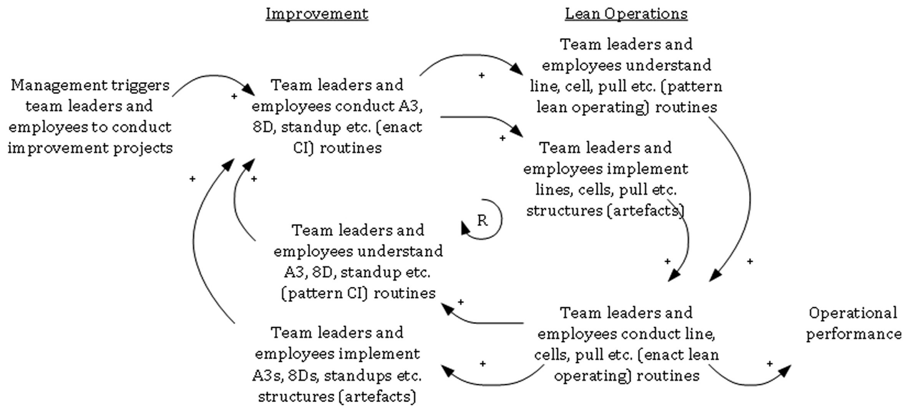


Figure 3.
Process model on the move from CI routines to lean operating routines

routines, in turn, helped to pattern their CI routines. In the successful Case A, conducting improvement activities led to changes in work design from two functional departments into lines, gradually increasing performance. Seeing the work become easier and their performance increase, triggered employees to continue improvements. These positive results encouraged managers to repeat these improvement cycles in other departments. In the successful Case B, the recurring improvement activities and discussions to implement 5S in the first department were sufficient to continue and achieve success also in the second department. Seeing the success of their colleagues, enacting and patterning their own CI routines, eased efforts to implement 5S for their peers. This is illustrated in Figure 3; enacting lean operating routines in turn helped team leaders and employees to develop a shared understanding of/pattern their CI routines.

Fourth, enacting lean operating routines also helped to implement CI artefacts. In the successful cases, A and B, CI artefacts were introduced to further extend their improvements: Plan-Do-Study-Act cycles for regular improvements combined with more advanced A3 or 8D formats for more complex issues. In the unsuccessful Case C, no CI artefacts were used. For some time, there were daily performance meetings to think of and implement improvements. However, there was no guidance around developing these or other CI routines before or during visits to the company. This is illustrated in Figure 3; enacting lean operating routines also helped team leaders and employees implement CI artefacts.

Continuous improvement of lean operating and improvement routines

Finally, as team leaders and employees implemented lean operating routines by enacting CI routines, their continued enactment also continued to improve both lean operating and CI routines. As is inherent in improvement activities and routine dynamics, lean operating and CI routines also continued to evolve. For example, once production lines were up and running in the first two departments of Case A, employees continued to adjust and develop them. And after 5S was implemented in the first department of Case B, employees continued to develop it further. This shows that lean operating and CI routines in themselves can also be a source of change: employees not only adjust how they enact a routine to the given circumstances, as the routine dynamics literature has pointed out, but also consciously modify the patterning and related artefacts as part of improvement activities. This interplay is illustrated in Figure 4; team leaders and employees enacting CI and lean operating routines shaped their patterning and helped them to continuously improve related artefacts and vice versa.

Involvement of different actors in changing routines and work design over time

Based on the process models for enacting and patterning lean operating and CI routines, the following section maps the involvement of different actors in the change process with illustrations of their respective contributions over time. These process maps characterize the underlying processes that allowed these firms to transition towards enacting and patterning CI and lean operating routines. In Case A, the CEO asked middle managers to conduct improvement projects and hired consultants to help them do so (see Figure 5). These middle managers then asked two team leaders to map current states, conduct root cause analyses, map future states, develop implementation plans, etc. They involved employees and together identified ways to improve their functional production into lines. This integrated approach resulted in changing the work design towards lean operating routines and in patterning and continued enacting of CI routines. The CEO and middle managers continued to support this process, for example, by hiring a CI manager and later also a Lean-minded Operational Officer. As such, top management asked middle managers and team leaders to enact CI routines and supported them in doing so. They were thus able to actively engage all organizational levels to implement lean operating routines resulting in an integrative approach.

Case B encountered unsuccessful and successful events surrounding 5S implementations (Figure 6). The first attempt was initiated by top managers in a top-down manner and was

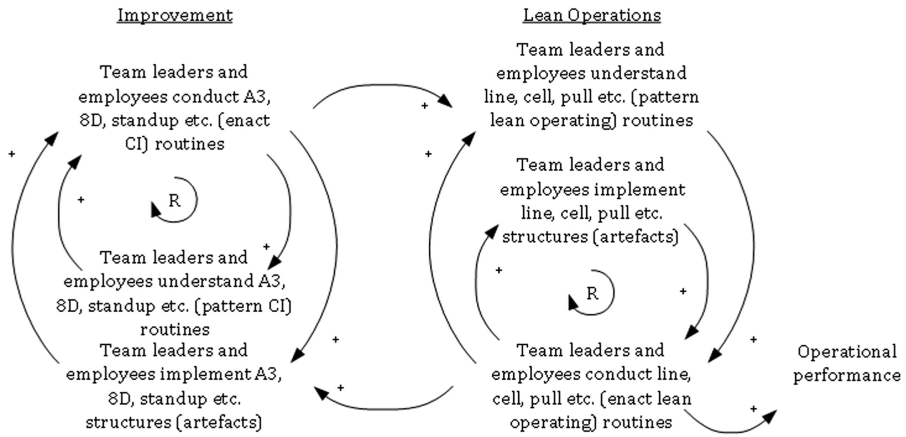


Figure 4.
Process model on the balanced enacting and patterning of lean operating and CI routines

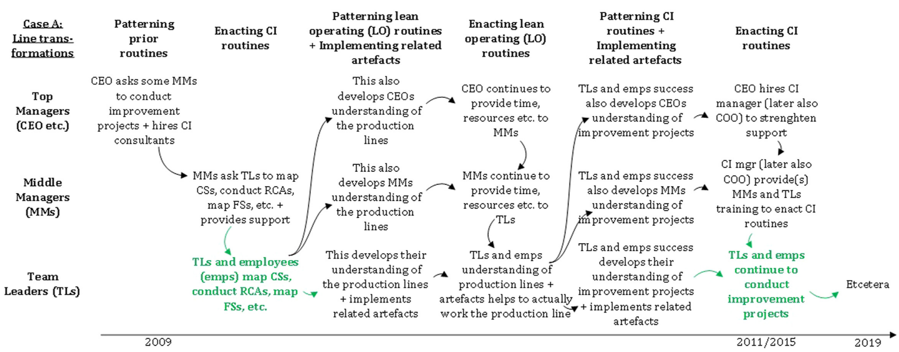


Figure 5.
Process map of line transformations Case A

unsuccessful. Middle managers were simply told to implement 5S and in turn ordered team leaders to do so without enacting any CI-related routines such as mapping current states, conducting root cause analysis, mapping future states, etc. Few employees understood the need and the implementation failed. In a second attempt, a new CI manager took a different approach in one of the plants, starting out with enacting cycles of 5S-related CI routines. They took time to analyse their current way of working, to identify what was adding value and what was not, to think of better ways of working, including 5S techniques, etc. He also encountered resistance but engaged in discussions and provided coaching. This approach enabled them to actively engage team leaders and employees in the implementation process and over time also spread to other departments.

Case C encountered unsuccessful events surrounding the "coup" and subsequent CI activities (Figure 7). One middle manager tried to implement a pull system using a limited set of carts, yet without involving team leaders and employees in mapping current states, conducting root cause analyses, mapping future states, etc. This prevented the development of a shared understanding of the pull system. Although eventually, employees did use the carts, no further improvement projects were conducted, resulting in a one-off implementation. When the CEO ordered all managers to reduce their lead times by half, experiences were mixed. People did not understand the need, and no improvement projects were enacted. Contrary to Case A and Case B, the managers at Case C did not actively engage all levels of the organization to implement lean operating routines. The absence of CI routines prevented managers and team leaders from patterning their lean operating routines, which means they lacked the understanding behind the work design changes.

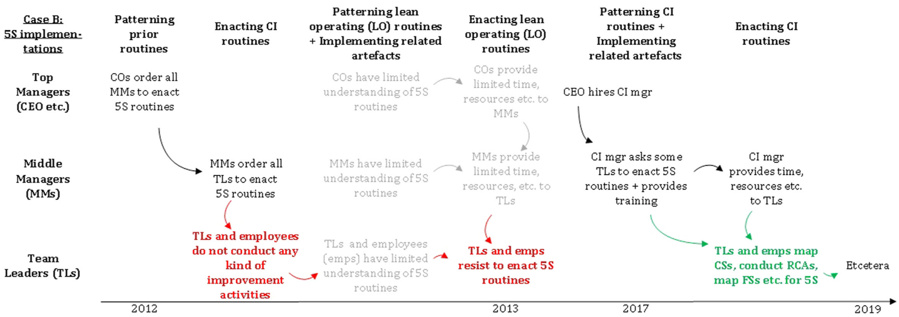


Figure 6.
Process map of 5S implementations at Case B

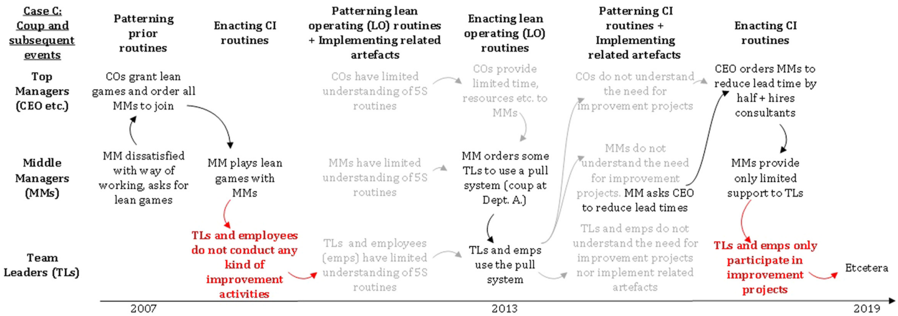


Figure 7.
Process map of coup and subsequent events at Case C

Discussion

Generic process model

This paper provides new insights into the interplay between lean operating and CI routines and how different actors can contribute to initiating and establishing these routines. A central idea is the interplay between the enacting and patterning of lean operating and CI routines. The specific process models (Figures 2–4) show how this interplay evolved in the different cases. From these specific process models, this paper proposes an abstract process model that indicates how this tandem relation could evolve in general (Figures 8–10). This proposed process model can be read as follows. Dissatisfied with prior routines, managers stimulate team leaders and employees to enact CI routines, such as kaizen events or A3 projects (Figure 8). Enacting CI routines helps team leaders and employees to first pattern and then enact lean operating routines and implement related artefacts, such as working with a Kanban system of cards or a two-bin system. This, in turn, helps team leaders and employees to pattern their CI routines and implement related artefacts, while both help to enact improved CI routines (Figure 9). When lean operating and CI routines are implemented, they do not become static but continue to develop due to their dynamic character (Figure 10).

The proposed process model is in line with earlier literature that proposed that lean operating and CI routines are best performed in tandem (Cua *et al.*, 2001; Flynn *et al.*, 1995a; Shah and Ward, 2003). This stream of literature, however, does not open up the black box to explain how these routines evolve. Wenzel *et al.* (2021) explained that rather than a static black box, organizational routines are dynamic and evolving. This paper unfolds how routines evolve in the context of lean production implementations. Shook (2010) and Liker (2020) explained that to change employee thinking it is important to change their behaviour. Our empirical evidence and the proposed process model support this notion. More specifically, this paper shows that CI routines do not stem from implementing lean operating routines. Rather, for managers to change team leaders' and employees' lean operations

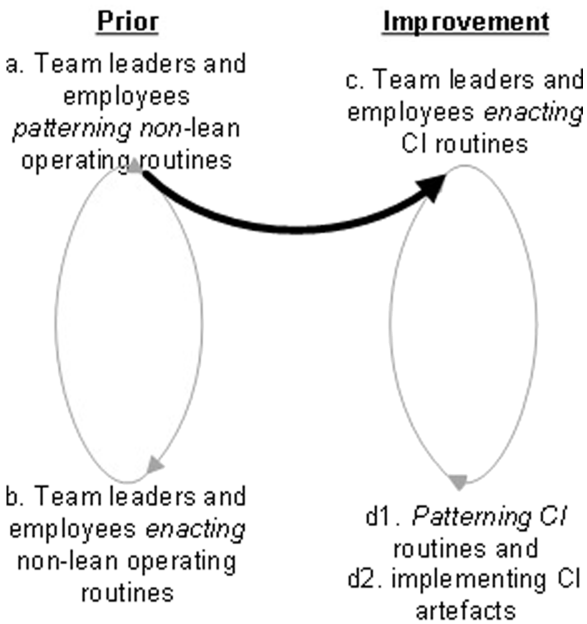


Figure 8.
Process model (1/3): the interplay between prior and lean routines

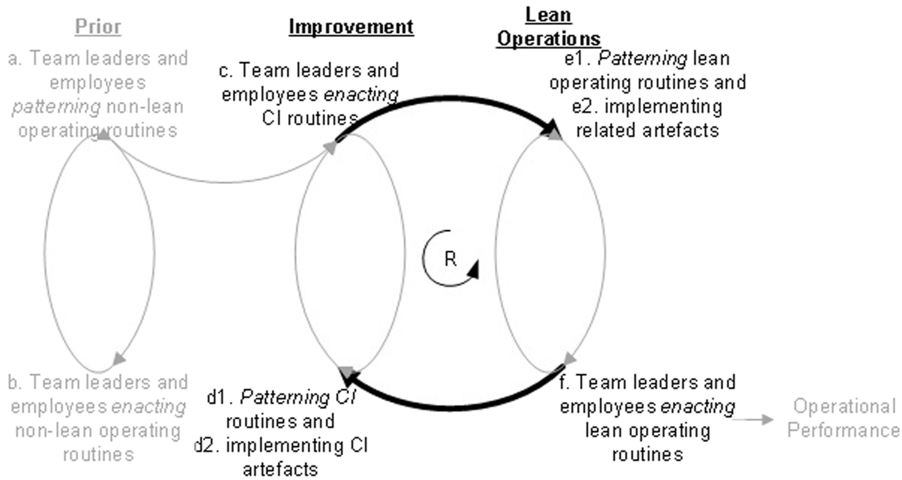


Figure 9.
Process model (2/3): the interplay between CI and lean operating routines

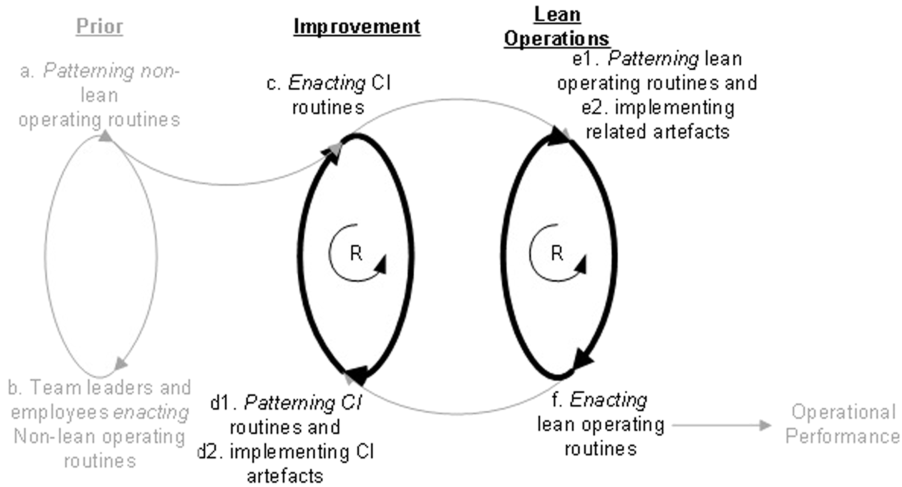


Figure 10.
Process model (3/3): the continued enacting and patterning of lean operating and CI routines

thinking, it is important to start with triggering their CI behaviour. This will help to change their shared lean operations thinking.

Keating *et al.* (1999) suggest that the main determinant of failure is the inability to manage an improvement project as a dynamic process. They conclude that activating cycles of employee pull help to sustainably improve processes without "command-and-control management". From a six sigma implementation study, De Mast *et al.* (2021) add that implementations of management systems such as six sigma and lean production are dynamic learning processes. This paper continues with this dynamic perspective, as it focuses on the interplay between lean operating and CI routines, and the role of different actors in establishing these routines. This paper refines earlier findings by Secchi and Camuffo (2016) that developing local improvement capabilities rather than centralized improvement expertise was linked to the best performers. And this paper expands on earlier insights that organizations may start implementing lean practices without CI routines, but that for advanced lean practitioners CI routines are always necessary (Knol *et al.*, 2019). This paper shows that the most advanced lean practitioners developed CI routines from the start.

What actors do to change routines and work design

The process maps (Figures 5–7) show the importance of active engagement of team leaders and employees by managers and strong connections between and across both levels. Top management support and leadership are crucial for implementing lean production as previous literature on infrastructural or CSFs has found (e.g. Achanga *et al.*, 2006; Sila and Ebrahimpour, 2003). Yet this initiative at the top level is most useful if it is directed at encouraging leaders to actively participate, and it can be counterproductive if it attempts to prescribe the actual implementation in a top-down manner. Middle managers can then advance the implementation, again not by implementing lean operating routines themselves but by stimulating team leaders and employees to enact CI routines and then adapt work design for lean operating routines. This approach transformed initial employee resistance into ownership and effective solutions, as employees themselves addressed the lean operating patterns. Scherrer-Rathje *et al.* (2009) explain that integrating top-down and bottom-up activities helps to implement lean production. The process model illustrates how top-down and bottom-up activities unfold over time, as it specifies the interaction between different hierarchical levels. While earlier findings had shown that the timing of CSFs matters (Knol *et al.*, 2018; Netland, 2016), the current research adds insights on how and by whom CI and lean operating routines could be enacted to create the most lasting impact in the change process.

Wenzel *et al.* (2021) explained that organizational routines can be developed through emergent and deliberate manners. This paper further unfolds the role of managers and team leaders and employees in lean production implementations; the most successful organizations in this study did not rely solely on management or expert-led interventions, nor did they leave improvements to team leaders and employees. Rather, they engaged team leaders and employees in enacting CI routines. While interventions in the work design create the structural conditions for enacting lean operations, they do not automatically create an understanding for the need for these changes, in particular, if conducted top-down and without coaching. Starting with enacting CI enables employees to take ownership and become actively involved in the subsequent enacting and patterning of lean operating and CI routines.

The proposed process model helps to understand when and why lean production implementations succeed but is not intended as a fail-safe "how to" guide to successful lean production implementations. There are always conditions of uncertainty and there can always be unforeseen events (Fiol and Lyles, 1985). Even after careful experimentation, new issues might still emerge, causing change to lead to routine corruption and regression towards or worsening of the previous state. The data show that, for example, in Case A, employees were allowed to make mistakes to learn from. In these unsuccessful implementations, routines regressed or worsened at first, but over time improved. In addition, work design in general (Sinha and Van De Ven, 2005) and lean production implementations in specific (Shah and Ward, 2003; Young, 1992) are always contingent on their environment. As such, the process model can serve as a framework for lean production implementations while remaining attentive to how the implementation process evolves, tailoring the approach to the people and circumstances at hand.

Alternative sequence of activities

Some authors argue that lean operating routines can also be patterned through management-driven improvements (e.g. Liker, 2004; Womack and Jones, 2003). Equifinality indicates there are different paths to the same outcome. The proposed process model indicates that the enacting and patterning of lean operating routines mutually reinforce each other. This means that the lean operating routine could improve over time. For example, implementing Kanban systems of cards helps to lower the level of work-in-progress (WIP). Employees experiencing this benefit might continue to strive for a better level of WIP. However, patterning lean operating routines in this way is not linked to enacting CI routines making it hard for employees to develop alternate lean operating routines, especially when top-down efforts by managers reinforce the prior way of leadership. This is in line with generic (e.g. Secchi and Camuffo, 2016) and specific findings on expert-driven interventions to implement lean production (e.g. Done *et al.*, 2011; Secchi and Camuffo, 2019) showing regression afterwards. And this is in line with findings on interventions to develop employees' CI routines (e.g. Anand *et al.*, 2021; Bateman, 2005) showing more sustainable results. For equifinality, it is important to consider the entire system as the outcome, including the patterns that developed the system. In that sense, the same lean operating routines can be the observable top of two entirely different systems.

Theoretical contributions

This paper provides new insights on how different actors can contribute to initiating and establishing lean operating and CI routines. This refines our practical, infrastructural and philosophical understanding of how to implement lean production. A practical perspective studies lean production from what is observable, its set of practices, routines, tools and techniques. There is a vast amount of research on lean production (e.g. Flynn *et al.*, 1995b; Krafcik, 1988; Shah and Ward, 2007) and how its bundles of routines are related to each other (e.g. Cua *et al.*, 2001; Dal Pont *et al.*, 2008; Flynn *et al.*, 1995a). This stream of research has typically taken a variance approach to study these practices and routines. This provides insights into the constellation of these bundles yet does not say much about how they develop over time. Taking a process view, incorporating the "who" and "how" next to the "what" of practices and routines (Jarzabkowski *et al.*, 2016; March and Sutton, 1997; Sinha and Van De Ven, 2005), this paper explains that rather than being implemented in isolation or even in conjunction with each other, sustainable lean practices and routines come about through team leader and employee enactment of the CI practices and routines. As such it provides a great way to integrate variance and process streams of literature to better understand lean production implementations.

Furthermore, this paper refines our infrastructural understanding of how to implement lean production. The literature provides many insights into which infrastructural (e.g. Ahmad *et al.*, 2003; Anand *et al.*, 2009; Sakakibara *et al.*, 1997) or success factors (e.g. Achanga *et al.*, 2006; Saraph *et al.*, 1989; Sila and Ebrahimpour, 2003) are critical for lean production implementation. These studies have adopted almost exclusively a variance perspective, even those with a longitudinal design (e.g. Bateman and Rich, 2003; Done *et al.*, 2011; Secchi and Camuffo, 2019). Building on process research, this paper maps the implementation process and moves from a contingency approach to a complexity approach (Jarzabkowski *et al.*, 2016; March and Sutton, 1997; Sinha and Van De Ven, 2005). Secchi and Camuffo (2019) already showed that the absence of obstacles and barriers is not sufficient for success; rather how the approach is organized matters for sustainable implementation. This study expands that insight by accounting for the role that different actors play at different times, which illustrates that management support and leadership are by no means sufficient conditions for success in themselves: they can be enacted in a top-down fashion that neglects the need for enacting and patterning CI routines and can jeopardize the entire implementation process.

Finally, the paper refines our philosophical understanding of how to implement lean production. Seminal works (Liker, 2004; Womack and Jones, 1996) comprehensively describe principles that are fundamental to a lean production system and have been applied many times. While each of these works stress the mutual reinforcement between lean operations and CI, they consistently and persistently present the lean operations principles before the CI-related principles (Liker, 2020; Womack and Jones, 2003). Additionally, the learning organization is typically portrayed as the final stage of lean maturity (Bessant and Francis, 1999; Hines *et al.*, 2004). This implicitly and sometimes explicitly suggests a temporal order. This paper challenges this constellation of principles and depiction of stages, as the findings clearly indicate that enacting CI is also essential at the start. While the initial version of "The Toyota Way" depicted problem-solving as the top of the pyramid (Liker, 2004), the more recent edition acknowledges that rather the principles are equal and interconnected like a jigsaw puzzle (Liker, 2020). This study provides evidence that CI principles are best not regarded as a final addition but as the primary mechanism for change both in terms of the temporal order and their importance for the implementation process.

Practical contributions

The proposed process model helps manufacturing managers, policy makers, consultants and educators to reconsider their approach to implement lean production or teach how to do so. First, lean operating structures and artefacts can easily be misused. For example, implementing 5S shadow boards in any top-down fashion to develop CI and learning, later on, neglects the interplay between enacting and patterning lean operating and CI routines to develop these routines. In such an approach, standardization can be locked in by implementing shadow boards directly, but it is unlikely that this will lead to employee-initiated improvement projects. From an employee's point of view, this is quite understandable. An employee might wonder why to start an improvement project if a manager ordered him to perform 5S in the first place. The employee would tend to expect the manager to continue this style of managing and tell them what to do next. When instead artefacts are implemented as the result of enacting CI routines, the artefacts will help to pattern lean operating routines and this will more likely result in continued improvement.

Second, the proposed process model indicates that also for infrastructural or CSFs some consideration is in order. Contrary to their definition, CSFs are no guarantee for success or to prevent failure. For example, in the unsuccessful case, management support was interpreted as supporting lean production implementation in a top-down fashion. Such an approach prevents team leaders and employees from starting A3 projects to identify and implement suitable lean operating routines, resulting in an insufficient implementation and possibly decay. Next to the "what" of such factors, it is, therefore, also important to incorporate the "who" and the "how" of CSFs. To ensure that over time, lean production implementations run along intended rather than unintended lines, it is not the CSFs but the enacting and patterning of lean operating and CI routines that is most important.

Third, this study also offers new insights compared to contingency theory. Previous research has shown that the suitability of lean practices depends on an organization's context or contingencies (e.g. McKone *et al.*, 1999; Shah and Ward, 2003; Sila, 2007). The process view illustrates that context and contingencies are not static but can evolve as part of the implementation process. By starting with CI activities, practitioners can mould the evolving routines to their specific situation and develop work designs that emerge as suitable for their requirements. Normative guidelines can act as inspiration for developing artefacts and patterning routines that are tested and refined as they are enacted. The resulting CI and lean operating routines may again show similarities that could be described as contingencies by future research.

As a final comment, there is discussion whether a "sense of urgency" is a suitable trigger or a hindrance to change (Stouten *et al.*, 2018). This paper also indicates that this can be a hindrance. If an organization is in urgent need of change, this is often addressed through top-down or expert interventions. However, such top-down interventions can hinder the enactment of CI routines by team leaders and employees, thereby obstructing the patterning and learning required for sustainable implementation. Creating social patterns is not as straightforward as installing a new software package – developing routines takes time. The findings of this paper indicate that the only way to speed up this process is to support team leaders and employees in enacting and patterning CI and lean operating routines and to provide sufficient coaching.

Limitations and future research

This paper focused on the interplay between generic routines. Though the comparative case analysis draws on specific events, the proposed process model is generic in nature. Future research can use the proposed process model to focus on the enacting and patterning of specific (clusters of) lean operating and CI routines. For example, which CI routines help to pattern and enact JIT, supplier or customer-related routines and ultimately improve performance? Or which lean operating routines help to pattern and enact Kaizens and A3 projects? This can provide more details to practitioners that want to implement lean production.

Furthermore, this paper focused on the role of management support and leadership. Future research can use the proposed process model to study the role of other CSFs. For example, which role does organizational culture play in building lean operating and CI routines? Or how does training help to enact and pattern lean operating and CI routines? Additionally, this paper focused on central concepts; the enacting and patterning of organizational routines. Future research could elaborate on adjacent concepts such as learning and un-learning, enforcing routines, truce and power. This will help to better understand the complex and dynamic nature of routine development.

This paper presents the results of a comparative analysis of retrospective case data. Although this allowed to study cases that were proven successful, it did not allow to keep a close track of the routine development. Certain events were not observed directly and interviewees might suffer from recall bias (Beckett *et al.*, 2001). Additionally, the data was coded by one author. This might have led to observation bias. Future research could take a more ethnographic approach to data collection and a more collective approach to data analysis to more thoroughly understand the implementation of lean production.

Another limitation of this study is its focus on manufacturing SMEs. As these organizations have their own inherent features and characteristics, findings cannot be generalized blindly. Future research can use the proposed process model to study lean production implementations in other contexts, such as more high-tech, larger organizations, more hierarchical enterprises, organizations that employ more different levels of education and less informal organizations.

Finally, this paper was limited to understanding the interplay between enacting and patterning lean operating and CI routines. Future research can take a longitudinal approach (e.g. interventionist research and design science [van Aken *et al.*, 2016; Oliva, 2019]) to develop interventions that pattern lean operating and CI routines in a variety of contexts, carefully considering the balance between managers and experts, and team leaders and employees. This will provide more detail to understand and help enact and pattern these routines in other organizations.

References

Achanga, P., Shehab, E., Roy, R. and Nelder, G. (2006), "Critical success factors for lean implementation within SMEs", *Journal of Manufacturing Technology Management*, Vol. 17 No. 4, pp. 460-471.

Adler, P.S., Goldoftas, B. and Levine, D.I. (1999), "Flexibility versus efficiency? A case study of model changeovers in the Toyota production system", *Organization Science*, Vol. 10 No. 1, pp. 43-68.

Ahmad, S., Schroeder, R.G. and Sinha, K.K. (2003), "The role of infrastructure practices in the effectiveness of JIT practices: implications for plant competitiveness", *Journal of Engineering and Technology Management*, Vol. 20, doi: 10.1016/S0923-4748(03)00017-1.

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

Anand, G., Chandrasekaran, A. and Sharma, L. (2021), "Sustainable process improvements: evidence from intervention-based research", *Journal of Operations Management*, Vol. 67 No. 2, pp. 212-236.

Aoki, K. (2020), "The roles of material artifacts in managing the learning–performance paradox: the kaizen case", *Academy of Management Journal*, Vol. 63 No. 4, pp. 1266-1299.

Argote, L. and Miron-Spektor, E. (2011), "Organizational learning: from experience to knowledge", *Organization Science*, Vol. 22 No. 5, pp. 1123-1137.

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

Bateman, N. and Rich, N. (2003), "Companies' perceptions of inhibitors and enablers for process improvement activities", *2International Journal of Operations and Production Management*, Vol. 23 No. 2, pp. 185-199.

Beckett, M., Da Vanzo, J., Sastry, N., Panis, C. and Peterson, C. (2001), "The quality of retrospective data: an examination of long-term recall in a developing country", *Journal of Human Resources*, Vol. 36 No. 3, pp. 593-625.

Beraldin, A.R., Danese, P. and Romano, P. (2019), "An investigation of the relationship between lean and well-being based on the job demands-resources model", *International Journal of Operations and Production Management*, Vol. 39 No. 12, pp. 1295-1322.

Bessant, J. and Caffyn, S. (1997), "High involvement innovation through continuous improvement", *International Journal of Technology Management*, Vol. 14 No. 1, pp. 7-28.

Bessant, J., Caffyn, S. and Gallagher, M. (2001), "An evolutionary model of continuous improvement behaviour", *Technovation*, Vol. 21 No. 2, pp. 67-77.

Bessant, J. and Francis, D. (1999), "Developing strategic continuous improvement capability", *International Journal of Innovation Management*, Vol. 19 No. 11, pp. 1106-1119.

Bicheno, J. and Holweg, M. (2016), *The Lean Toolbox*, 5th ed., Picsie Books, Buckingham.

Bortolotti, T., Boscari, S. and Danese, P. (2015), "Successful lean implementation: organizational culture and soft lean practices", *International Journal of Production Economics*, Vol. 160, pp. 182-201.

Cacciatori, E. (2012), "Resolving conflict in problem-solving: systems of artefacts in the development of new routines", *Journal of Management Studies*, Vol. 49 No. 8, pp. 1559-1585.

Call-Cummings, M. (2017), "Establishing communicative validity: discovering theory through practice", *Qualitative Inquiry*, Vol. 23 No. 3, pp. 192-200.

Cua, K.O., McKone, K.E. and Schroeder, R.G. (2001), "Relationships between implementation of TQM, JIT, and TPM and manufacturing performance", *Journal of Operations Management*, Vol. 19 No. 6, pp. 675-694.

D'Adderio, L. (2008), "The performativity of routines: theorising the influence of artefacts and distributed agencies on routines dynamics", *Research Policy*, Vol. 37 No. 5, pp. 769-789.

Dal Pont, G., Furlan, A. and Vinelli, A. (2008), "Interrelationships among lean bundles and their effects on operational performance", *Operations Management Research*, Vol. 1 No. 2, pp. 150-158.

De Mast, J., Lameijer, B.A., Linderman, K. and Van de Ven, A. (2021), "Exploring the process of management system implementation: a case of Six Sigma", *International Journal of Operations and Production Management*, Vol. 42 No. 13, pp. 1-24.

Done, A., Voss, C. and Rytter, N.G. (2011), "Best practice interventions: short-term impact and long-term outcomes", *Journal of Operations Management*, Vol. 29 No. 5, pp. 500-513.

Eisenhardt, K.M. (1989), "Building theories from case study research", *The Academy of Management Review*, Vol. 14 No. 4, pp. 532-550.

Eisenhardt, K.M. and Graebner, M.E. (2007), "Theory building from cases: opportunities and challenges", *The Academy of Management Journal*, Vol. 50 No. 1, pp. 25-32.

Feldman, M.S. (2000), "Organizational routines as a source of continuous change", *Organization Science*, Vol. 11 No. 6, pp. 611-629.

Feldman, M.S. (2016), "Routines as process: past, present, and future", *Organizational Routines: A Process Perspective*, Oxford University Press, Oxford, pp. 23-46.

Feldman, M.S. and Pentland, B.T. (2003), "Reconceptualizing organizational routines as a source of flexibility and change", *Administrative Science Quarterly*, Vol. 48 No. 1, pp. 94-118.

Fereday, J. and Muir-Cochrane, E. (2006), "Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development", *International Journal of Qualitative Methods*, Vol. 5 No. 1, pp. 80-92.

Fiol, C.M. and Lyles, M.A. (1985), "Organizational learning", *Academy of Management Review*, Vol. 10 No. 4, pp. 803-813.

Flick, U. (2009), *An Introduction to Qualitative Research*, 4th ed., SAGE Publications, London.

Flynn, B.B., Sakakibara, S. and Schroeder, R.G. (1995a), "Relationship between JIT and TQM: practices and performance", *Academy of Management Journal*, Vol. 38 No. 5, pp. 1325-1360.

Flynn, B.B., Schroeder, R.G. and Sakakibara, S. (1995b), "The impact of quality management practices on performance and competitive advantage", *Decision Sciences*, Vol. 26 No. 5, pp. 659-691.

Galeazzo, A., Furlan, A. and Vinelli, A. (2021), "The role of employees' participation and managers' authority on continuous improvement and performance", *International Journal of Operations and Production Management*, Vol. 41 No. 13, pp. 34-64, doi: 10.1108/IJOPM-07-2020-0482.

Giddens, A. (1984), *The Constitution of Society: Outline of the Theory of Structuration*, International Journal of Operations & Production Management, Berkeley, Los Angeles.

Golden, B.R. (1992), "The past is the past - or is it? The use of retrospecitve accounts as indicators of strategy", *Academy of Management Journal*, Vol. 35 No. 4, pp. 848-860.

Hackman, J.R. and Wageman, R. (1995), "Total quality management: empirical, conceptual, and practical issues", *Administrative Science Quarterly*, Vol. 40 No. 2, pp. 309-342.

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

Holweg, M., Davies, J., De Meyer, A., Lawson, B. and Schmenner, R. (2018), *Process Theory: The Principles of Operations Management*, Oxford University Press, New York, NY.

Hutchins, E. (1995), *Cognition in the Wild*, MIT Press, Cambridge, MA.

Imai, M. (1986), *Kaizen - the Key to Japan's Competitive Success*, Random House Business Division, New York, NY.

Jarzabkowski, P., Kaplan, S., Seidl, D. and Whittington, R. (2016), "On the risk of studying practices in isolation: linking what, who, and how in strategy research", *Strategic Organization*, Vol. 14 No. 3, pp. 248-259.

Jick, T.D. (1979), "Mixing qualitative and quantitative methods: triangulation in action", *Administrative Science Quarterly*, Vol. 24 No. 4, pp. 602-661.

Karlsson, C. and Åhlström, P. (1996), "Assessing changes towards lean production", *Journal of Operations and Production Management*, Vol. 16 No. 2, pp. 24-41.

Keating, E.K., Oliva, R., Repenning, N., Rockart, S. and Sterman, J. (1999), "Overcoming the improvement paradox", *European Management Journal*, Vol. 17 No. 2, pp. 120-134.

Ketokivi, M. and Choi, T. (2014), "Renaissance of case research as a scientific method", *Journal of Operations Management*, Elsevier B.V., Vol. 32 No. 5, pp. 232-240.

Knol, W.H., Slomp, J., Schouteten, R.L.J. and Lauche, K. (2018), "Implementing lean practices in manufacturing SMEs: testing 'critical success factors' using Necessary Condition Analysis", *International Journal of Production Research*, Taylor & Francis, Vol. 56 No. 11, pp. 3955-3973.

Knol, W.H., Slomp, J., Schouteten, R.L.J. and Lauche, K. (2019), "The relative importance of improvement routines for implementing lean practices", *International Journal of Operations and Production Management*, Vol. 39 No. 2, pp. 214-237.

Krafcik, J.F. (1988), "Triumph of the lean production system", *Sloan Management Review*, Vol. Fall, pp. 41-52.

Lamming, R. (1996), "Squaring lean supply with supply chain management", *International Journal of Operations and Production Management*, Vol. 16 No. 2, pp. 183-196.

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

Liker, J.K. (2020), *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*, 2nd ed., McGraw-Hill Education, New York, NY.

March, J.G. and Sutton, R.I. (1997), "Crossroads - organizational performance as a dependent variable", *Organization Science*, Vol. 8 No. 6, pp. 698-706.

McCutcheon, D.M. and Meredith, J.R. (1993), "Conducting case study research in operations management", *Journal of Operations Management*, Vol. 11 No. 3, pp. 239-256.

McKone, K.E., Schroeder, R.G. and Cua, K.O. (1999), "Total productive maintenance: a contextual view", *Journal of Operations Management*, Vol. 17 No. 2, pp. 123-144.

Meredith, J. (1998), "Building operations management theory through case and field research", *Journal of Operations Management*, Vol. 16 No. 4, pp. 441-454.

Miles, M.B., Huberman, A.M. and Saldaña, J. (2013), *Qualitative Data Analysis: A Methods Sourcebook*, 3rd ed., SAGE Publications, California.

Nakajima, S. (1988), *Introduction to Total Productive Maintenance*, Productivity Press, Portland.

Nelson, R.R. and Winter, S.G. (1982), *An Evolutionary Theory of Economic Change*, Harvard University Press, Boston, MA.

Netland, T.H. (2016), "Critical success factors for implementing lean production: the effect of contingencies", *International Journal of Production Research*, Vol. 54 No. 8, pp. 2433-2448.

Nicolini, D., Mengis, J. and Swan, J. (2012), "Understanding the role of objects in cross-disciplinary collaboration", *Organization Science*, Vol. 23 No. 3, pp. 612-629.

Oliva, R. (2019), "Intervention as a research strategy", *Journal of Operations Management*, Vol. 65, pp. 710-724.

Ōno, T. (1988), *Toyota Production System: Beyond Large-Scale Production*, Productivity Press, Portland.

Peng, D.X., Schroeder, R.G. and Shah, R. (2008), "Linking routines to operations capabilities: a new perspective", *Journal of Operations Management*, Vol. 26 No. 6, pp. 730-748.

Pentland, B.T. and Feldman, M.S. (2008), "Designing routines: on the folly of designing artifacts, while hoping for patterns of action", *Information and Organization*, Elsevier, Vol. 18 No. 4, pp. 235-250.

Pettigrew, A.M. (1990), "Longitudinal field research on change: theory and practice", *Organization Science*, Vol. 1 No. 3, pp. 267-292.

Rerup, C. and Feldman, M.S. (2011), "Routines as a source of change in organizational schemata: the role of trial-and-error learning", *Academy of Management Journal*, Vol. 54 No. 3, pp. 577-610.

Rother, M. (2010), *Toyota Kata*, 2nd ed., Tata McGraw Hill, New Delhi.

Rother, M. and Shook, J. (1999), *Learning to See*, Lean Enterprise Institute, Brookline.

Sakakibara, S., Flynn, B.B., Schroeder, R.G. and Morris, W.T. (1997), "The impact of just-in-time manufacturing and its infrastructure on manufacturing performance", *Management Science*, Vol. 43 No. 9, pp. 1246-1257.

Saraph, J.V., Benson, P.G. and Schroeder, R.G. (1989), "An instrument for measuring the critical factors of quality management", *Decision Sciences*, Vol. 20 No. 4, pp. 810-829.

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 and Production Management*, Vol. 36 No. 1, pp. 61-85.

Secchi, R. and Camuffo, A. (2019), "Lean implementation failures: the role of organizational ambidexterity", *International Journal of Production Economics*, Vol. 210, pp. 145-154.

Shah, R. and Ward, P.T. (2003), "Lean manufacturing: context, practice bundles, and performance", *Journal of Operations Management*, Vol. 21 No. 2, pp. 129-149.

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.

Shook, J. (2010), "How to change a culture: lessons from NUMMI", *MIT Sloan Management Review*, Vol. 51 No. 2, pp. 62-68.

Sila, I. (2007), "Examining the effects of contextual factors on TQM and performance through the lens of organizational theories: an empirical study", *Journal of Operations Management*, Vol. 25 No. 1, pp. 83-109.

Sila, I. and Ebrahimpour, M. (2003), "Examination and comparison of the critical factors of total quality management (TQM) across countries", *International Journal of Production Research*, Vol. 41 No. 2, pp. 235-268.

Sinha, K.K. and Van De Ven, A.H. (2005), "Designing work within and between organizations", *Organization Science*, Vol. 16 No. 4, pp. 389-408.

Stouten, J., Rousseau, D.M. and De Cremer, D. (2018), "Successful organizational change: integrating the management practice and scholarly literature", *Academy of Management Annals*, Vol. 12 No. 2, pp. 752-788.

Stuart, I., McCutcheon, D., Handfield, R., McLachlin, R. and Samson, D. (2002), "Effective case research in operations management: a process perspective", *Journal of Operations Management*, Vol. 20 No. 5, pp. 419-433.

Sugimori, Y., Kusunoki, K., Cho, F. and Uchikawa, S. (1977), "Toyota production system and Kanban system materialization of just-in-time and respect-for-human system", *International Journal of Production Research*, Vol. 15 No. 6, pp. 553-564.

van Aken, J., Chandrasekaran, A. and Halman, J. (2016), "Conducting and publishing design science research: inaugural essay of the design science department of the Journal of Operations Management", *Journal of Operations Management*, Elsevier B.V., Vol. 47 No. 48, pp. 1-8.

Van De Ven, A.H. and Poole, M.S. (2005), "Alternative approaches for studying organizational change", *Organization Studies*, Vol. 26 No. 9, pp. 1377-1404.

Van Maanen, J. (1979), "The fact of fiction in organizational ethnography", *Administrative Science Quarterly*, Vol. 24 No. 4, pp. 539-550.

Wenzel, M., Danner-Schröder, A. and Spee, A.P. (2021), "Dynamic capabilities? Unleashing their dynamics through a practice perspective on organizational routines", *Journal of Management Inquiry*, Vol. 30 No. 4, pp. 395-406.

Womack, J.P. and Jones, D.T. (1996), *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, Simon & Schuster, New York, NY.

Womack, J.P. and Jones, D.T. (2003), *Lean Thinking: Banish Waste and Create Wealth in Your Corporation, Revised and Updated*, Free Press, New York, NY.

Womack, J.P., Jones, D.T. and Roos, D. (1991), *The Machine That Changed the World*, Harper Perennial, New York, NY.

Yin, R.K. (2013), *Case Study Research: Design and Methods*, 5th ed., SAGE Publications, Thousand Oaks.

Young, S.M. (1992), "A framework for successful adoption and performance of Japanese manufacturing practices in the United States", *Academy of Management Review*, Vol. 17 No. 4, pp. 677-700.

Zollo, M. and Winter, S.G. (2002), "Deliberate learning and the evolution of dynamic capabilities", *Organization Science*, Vol. 13 No. 3, pp. 339-351.

Appendix 1
Interview guide

This appendix shows the interview guide that was used during the final case study interviews (Table A1). This guide was developed and grew over the course of the study. In general, the first interviews were more open, allowing for new subjects and relations to be found, while the last interviews were more structured to help check for missing information. This approach, from more open to more structured, was also taken in each individual interview. For example, in the final more structured interviews, the first questions were more open while subsequent questions could be more structured. These interviews started with questions such as: "*What do you do to improve your work?*". Depending on the answer, questions were specified based on the interview guide. For example, "*What do you do to create understanding of the basic values of CI?*". In this sense, instead of a strict list of questions that were asked in this exact order, the guide acted as a checklist to ensure that all topics were covered. Concepts such as enacting and patterning routines and related artefacts were not addressed directly but were linked to the interview data during data analysis. This guide was translated from Dutch, which is the native language of the interviewees.

Topics	Subjects	Example questions
Introduction	Introduction	*If necessary: personal introduction*
	Reason for the interview	Explanation of the subject, purpose, approach and time required
	Questions	Explanation that they can ask questions any time
	Audio recording	Is it okay to audio record this interview? Explanation of reason why and use of the data and destruction of the data
	Functionalities	What is your job description? What is it that you do on a regular day?
Open	Lean operations	*If necessary: explanation of lean operations and CI* What do you do in operations?
	CI	What do you do in improvement?
	Organizational routines (enacting and patterning)	What do you do to develop routines?
	Critical success factors	What do you do to develop conditions necessary to enact lean operating and/or CI routines?
Ostensive aspect	Patterning lean operating routines	How do you develop employees' shared understanding of lean operating routines?
	Patterning CI routines	How do you develop employees' shared understanding of CI routines?
Performative aspect	Enacting lean operating routines	How do you develop employees' enactment of lean operating routines?
	Enacting CI routines	How do you develop employees' enactment of CI routines?
Related artefacts	Artefacts related to lean operations	How do you implement artefacts related to lean operating routines?
	Artefacts related to CI	How do you implement artefacts related to CI routines?
Operations (Shah and Ward, 2007, p. 799)	Supplier feedback	What do you do to "provide regular feedback to suppliers about their performance"?
	JIT delivery	What do you do to ensure "that suppliers deliver the right quantity at the right time in the right place"?
	Developing suppliers	What do you do to "develop suppliers so they can be more involved in the production process of the focal firm"?
	Involved customers	What do you do to "focus on [the] firm's customers and their needs"?
	Pull	What do you do to "facilitate JIT production including Kanban cards"?
	Flow	What do you do to "establish mechanisms that enable and ease the continuous flow of products"?
	Low setup	What do you do to "reduce process downtime between product changeovers"?
	Controlled processed	What do you do to "address equipment downtime through total productive maintenance and thus achieve a high level of equipment availability"?
	Productive maintenance	What do you do to "ensure each process will supply defect free units to subsequent process"?
	Involved employees	What do you do to "involve cross-functional employees in problem solving"?

(*continued*)

Table A1. Final interview guide for final case interviews

Topics	Subjects	Example questions
Improvement routines (Bessant *et al.*, 2001)	Understanding CI	What do you do to create understanding of “the basic values of CI”?
	Getting the CI habit	What do you do to “generate sustained involvement in CI”?
	Focussing CI	What do you do to “link CI activities to the strategic goals of the company”?
	Leading the way	What do you do to “lead, direct and support the creation and sustaining of CI behaviours”?
	Aligning CI	What do you do to “create consistency between CI values and behaviour and the organizational context”?
	Shared problem solving	What do you do to “move CI activity across organizational boundaries”?
	CI of CI	What do you do to “strategically manage the development of CI”?
	The learning organization	What do you do to “enable learning to take place and be captured at all levels”?
Critical success factors (Knol *et al.*, 2018)	Top management support	What do you do to assume responsibility and involvement from top management?
	Shared improvement vision	What do you do to develop, share and follow company-wide, long-term direction, objectives and goals?
	Good communication	What do you do to exchange ideas, information and knowledge honestly, clearly and transparently in all organizational directions?
	Leadership	What do you do to get team leaders to facilitate, coordinate and balance improvements from shop floor employees?
	People focus	What do you do to get organizational systems to help employees to do their work versus employees being bound to organizational systems?
	Learning focus	What do you do to share both positive and negative experiences and consider mistakes opportunities for improvement?
	Sufficient resources	What do you do to make sufficient time and money available for training and improvement activities?
	Improvement training	What do you do to provide training for managers and shop floor employees in improvement concepts, tools, techniques and team building?
	Performance Management system	What do you do to measure and display process data from all levels to control production, prevent defects and indicate opportunities?
	Supplier link	What do you do to get suppliers to provide and get feedback and rate them to select a limited number of suppliers?
	Customer link	What do you do to get customers to provide and get feedback and cooperate for improvement?
	Support congruence	What do you do to align employee targets, assessments and rewards of all departments with the improvement vision?
Closing	Remainders	Is there anything else related to lean operations and/or CI that you would like to share?
	Focus	Of all we have discussed, what has been the most important?
	Follow-up	*Explanation (repetition) of the use of the data and the remainder of this research*

Table A1.

Appendix 2
Case timelines

This appendix shows the process models that were made per case (Figures A1–A3). The arrows indicate the order in which activities and events took place.

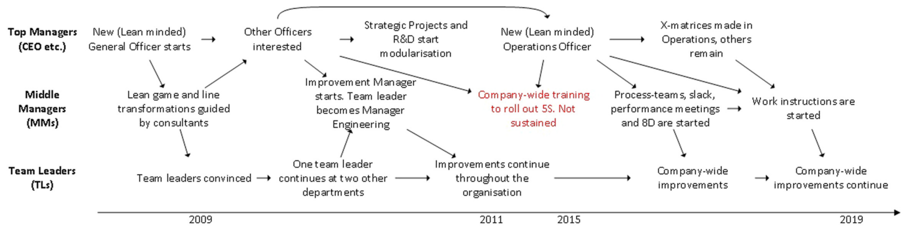


Figure A1. Timeline of Case A

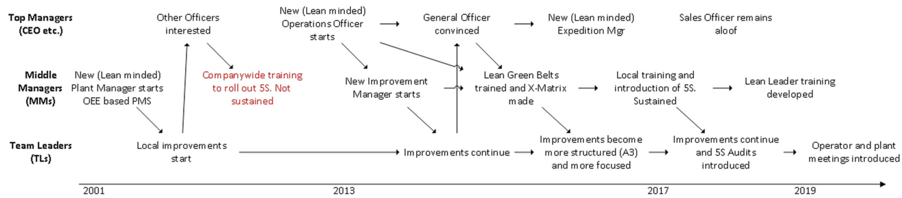


Figure A2. Timeline of Case B

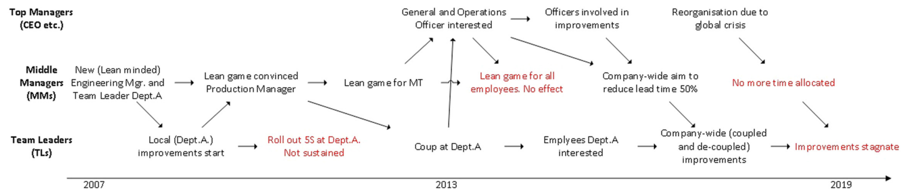


Figure A3. Timeline of Case C

Corresponding author

Wilfred H. Knol can be contacted at: wilfred.knol@han.nl