Becoming Lean: a process model of Lean production

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Abstract

There is a consensus among scholars studying Lean production that practices constituting Lean production should be introduced sequentially. However, previous literature on a sequence of Lean production is either prescriptive or analyses a sequence of introduction of Lean production from a change management perspective. A qualitative inquiry based on narrative strategy was used to generate a process model of becoming Lean. The model argues that organizations become Lean through four stages: exposing artifacts supporting individual action dispositions, increasing coherence of action dispositions, exposing coherence of action dispositions for group problem solving, and introducing pacing and automatic triggers of action dispositions.

Keywords: Lean production, Sequence, Process model

Introduction

Lean production became a common set of guiding principles and practices for organizations seeking to increase operational efficiency. It holds an answer to one of the core questions of operations management: how efficiency and flexibility may be achieved simultaneously (Adler et al., 2009; Womack et al., 1990). Lean production may be defined as „an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability“ (Shah and Ward, 2007 p. 791).

Variance and process models of Lean production are proposed to facilitate efforts of organizations to become Lean. Variance models explain phenomena through antecedents, constitutive concepts, and effects, process models – through a sequence of events (Langley, 1999). Variance approach is the most prevalent form of theorizing of Lean production. For example, Shah and Ward (2007) proposed that eleven mutually reinforcing supplier-related, customer-related, and internally-related practices constituted

Lean production. These practices contribute to the reduction of variability and elimination of waste, what increase the speed of flow of products and materials through production system (Shah and Ward, 2003). Research on Lean production based on variance approach, resulted in important knowledge about antecedents of Lean production practices (e.g., Hallgren and Olhager, 2009), relationships of practices of Lean production (Womack et al., 1990; Shah and Ward, 2003, 2007) and their influence for operational and business performance (e.g., Schmenner and Swink, 1998; Hofer et al., 2012; Cua et al., 2001).

Despite useful knowledge on antecedents, constitutive practices and effects of Lean production, the process of becoming Lean is still highly equivocal. Moyano-Fuentes et al. (2012) argue that there is a "large degree of consensus about the need for LP to be implemented sequentially" (p. 571). However, the nature of this sequence has not been well understood yet. The knowledge of the patterns of events leading to Leanness is essential because Lean production consists of high amount socio-technical practices. It is highly improbable that organizations could attend to all of them at once. Even more, Lean production practices are supported by particular values (Dahlgaard and Dahlgaard-Park, 2006), and their nurturing is a time-consuming process.

There are two groups of process models of Lean production. The first group of models addresses introduction of Lean production from the perspective of change management. For example, Mostafa et al. (2013) suggested that the following stages constitute process model of becoming Lean: conceptualization, implementation design, implementation and evaluation, and completion of transformation. The second group of models depicts a sequence of introduction of Lean productions elements. For example, Ahlstrom (1998) proposed that introduction of the most elements of Lean production should start in parallel, except "Continuous improvement" which should be introduced after values of that are behind practices of "Zero defects" and "Delayering" become unquestioned. Given under-developed research on process models of Lean production and compelling arguments for the sequentially of Lean production, *we seek to reveal a sequential pattern of becoming Lean in this article.*

A qualitative inquiry based on narrative strategy (Pentland, 1999; Langley, 1999) was used to generate a processual explanation of becoming Lean. An organization adept in Lean production was selected. Narrative interviews, non-participant observation, and archival documents analysis were employed to collect data on a sequence of events leading to Leanness. The timing of introduction, diffusion and bundling of methods of Lean production was determined. The coding (Gioia et al., 2013) of the affordances (effects of Lean production methods for organizing) of practices of Lean production taking into account the timing and diffusion of the methods was initiated. This approach allowed to propose the stages of becoming Lean that is based on effects of Lean production methods for organizing.

The inductive study of an organization that is practicing Lean production for ten years, allowed to propose that four sequential stages could explain the process of becoming Lean: exposing artifacts supporting individual action dispositions, increasing coherence of action dispositions, exposing coherence of action dispositions for group problem solving, and introducing pacing and automatic triggers of action dispositions.

The article consists of four sections. The process and variance explanations of Lean production are contrasted in the first section. The empirical research design of the qualitative inquiry based on narrative strategy is grounded in the second section. The sequence of events of becoming Lean is presented in the fourth section. Finally, the findings are theorized to propose a process model of becoming Lean and theoretical contributions of the model are discusses.

Literature review

The predecessor of contemporary Lean production systems is just-in-time or Toyota production system (TPS) which was designed in the 1980s in Toyota (Schonberger, 2007). The worldwide adoption of TPS started in the 1990s when Womack et al. (1990) provided a compelling explanation of elements of TPS and suggested to use Lean as a synonym for the practices pioneered by Toyota (Hallgren and Olhager, 2009). Womack and Jones (1996) proposed five principles constituting Lean production: value stream, flow, pull, and perfection. These principles became guiding marks for organizations adopting Lean production.

Lean may be conceived as a manufacturing paradigm and as performance capability (Narasimhan et al., 2006). Lean as production paradigm is defined as „an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability“ (Shah and Ward, 2007 p. 791). The leanness of production as a performance capability is defined as if production "is accomplished with minimal waste due to unneeded operations, inefficient operations or excessive buffering" (Narasimhan et al., 2006, p.443). The organizations that adopted Lean production and achieved Leanness of its production enjoy increased productivity (Schmenner and Swink, 1997), superior cost effectiveness, high conformance quality of products (Narasimhan et al., 2006). Given these definitions, *a process of becoming Lean is a sequence of events enacted by a company to achieve Leanness of production.*

Variance and process models of Lean production are proposed to facilitate efforts of organizations to become Lean. Variance models explain phenomena through antecedents, constitutive concepts, and effects, process models – through a sequence of events (Langley, 1999). The variance model of Lean production, proposed by Shah and Ward (2003, 2007), is provided in Figure 1.

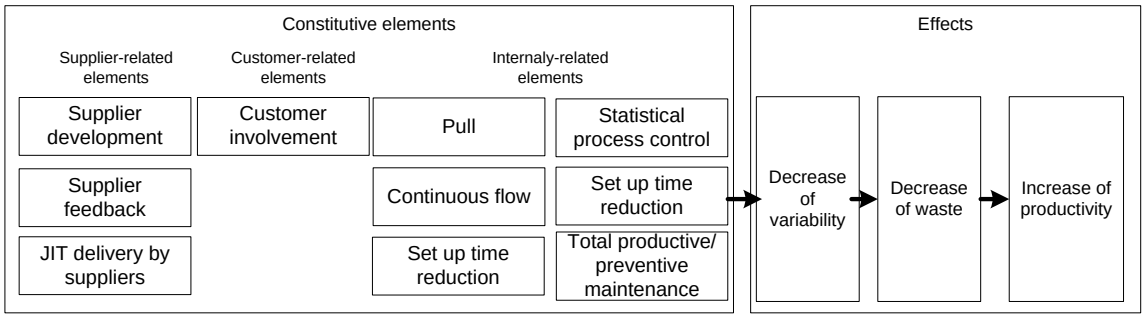


Figure 1 – Variance model of Len production

Lean production draws heavily on a concept of swift and even flow. The concept argues that "productivity of any process increases with the speed by which materials flow through the system, and it falls with increases with variability associated with the flow, be it variability of supply, demand or processing time" (Schmenner and Swink, 1997, p. 102). Accordingly, the objective of the Lean production is to "eliminate waste by reducing or minimizing variability related to supply, processing time and demand (Shah and Ward (2007). Ten supplier-related, customer-related and internally related elements reinforce each other to achieve the objective. Supplier-related and Customer-related elements help to explain the reduction of variability of supply and demand. The internally related elements explain how the variability of processing time is narrowed. The decrease of the variability of supply, demand and processing time allows reducing waste, such as overproduction, waiting time, transportation, unnecessary processing steps, raw materials inventory, and defects. Finally, the productivity of production system increase.

Variance models help to explain phenomena by propositions of the relationships among antecedents, constitutive elements, and effects. However, variance models do not inform on a sequence of events leading to outcomes (Langley, 1999). Process models explain phenomena through patterns of events, describing how they evolve and why they evolve in this way (Van de Ven and Huber, 1990). A process model of Lean production explains the typical sequence of events leading to Leanness.

If the sequence of Lean production exist, at all? Lean production is a socio-technical system, which is constituted by material and symbolic aspects. Particular tools/practices subsequently constitute these elements. 48 practices/tools constitute ten elements of Lean production model proposed by Shah and Ward (2007). It is highly improbable that 48 tools could be implemented in parallel. Even more, the most of Lean practices are socio-material assemblages, i.e., contains material and cultural dimensions. For example, the concept of value-adding activities is heavily rooted in the external orientation (Dahlgaard and Dahlgaard-Park, 2006). Elimination of non-value activates is not just a material practice. It is supported by attitudes that anything that customer does not value is waste. The development of values supporting Lean production tool is a time-consuming process. Finally, Shah and Ward (2003, 2007) propose some of the elements are more mutually reinforcing than other ones. For example, to produce right amounts of products in the right time, firms use pull approach and Kanban's ("Pull") together with just-in-time delivery of raw materials ("JIT delivery by suppliers"). It implies that there is more viable to bundle their introduction. These arguments allow arguing that at least some of the elements of Lean production should be introduced subsequently.

There are two groups of process models of Lean production. The first group of models addresses introduction of Lean production from the perspective of change management. The second depicts the sequence of introduction of Lean productions practices. Mostafa et al. (2008) reviewed twenty-eight implementation frameworks of Lean production. After a review, Mostafa et al. (2013) suggested that the following stages constitute implementation of Lean production: conceptualization, implementation design, implementation and evaluation, and completion of transformation.

The second group of process models of Lean production depicts the sequence of introduction of Lean productions practices. Ahlstrom (1998) suggested that Lean practices are both in parallel and sequentially (Figure 2).

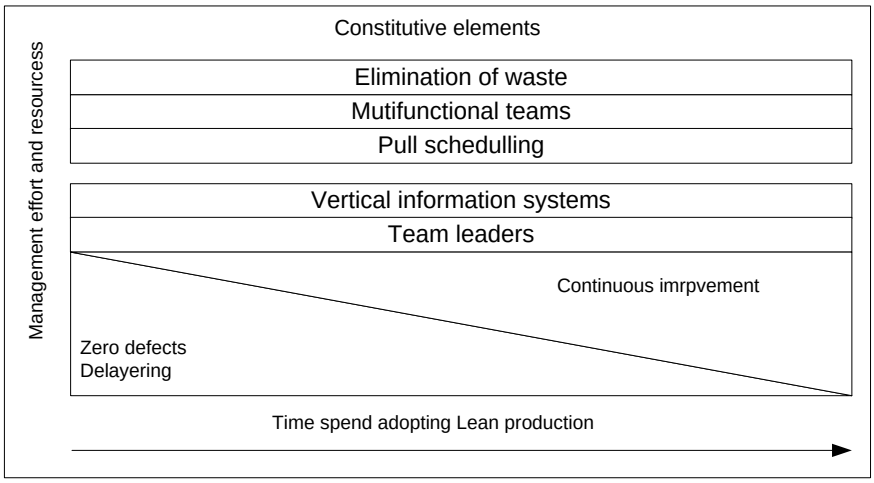


Figure 2 – Process model of Lean production (Ahlstrom. 1998)

He suggested that "Zero defects" and "Delayering" practices should be introduced early. In parallel with these practices, a set of core principles (i.e., "Elimination of waste,"

"Multifunctional teams," "Pull scheduling") are introduced together with supporting principles (i.e., "Vertical information systems," "Team Leaders"). Introduction of "Continuous improvement" should follow. In summary, he proposes that most practices should start in parallel, except "Continuous improvement" which should be introduced after values of that are behind "Zero defects" and "Delayering" become unquestioned.

Process models of Lean productions are limited. At the same time, there are good reasons to believe that sequential pattern of Lean production exists. In this article, we seek to answer a question – *what sequence of events lead to becoming Lean?* This question is still not completely answered. First, a group of process models, which addresses the introduction of Lean production from the perspective of change management, provide important answer how to manage the introduction of Lean production. The most of them are grounded in episodic change perspective (Weick and Quinn, 1999). The second group of process models that addresses the sequence of introduction of Lean production illuminate some aspects of sequentially of Lean production. However, most of the process models of Lean production are prescriptive and do not provide the arguments behind the sequence (e.g., Feld, 2000; Nightingale et al., 2002; Rivera et al., 2007; Chen 2009). The process model proposed by Ahlstrom (1998) suggest that rather little sequentially of Lean production exists. It provides a starting proposition, which is tested by a qualitative study of organization adept in Leanness.

Methods

Research design. The inductive research design was employed we seek to reveal a sequential pattern of becoming Lean. The company (further PCB Electronics) that manufactures printed circuit boards and other electronic equipment were selected. The selected company was suitable for the study of a sequence of events leading to Leanness. It participates in a global sector of electronic products, which is a competitive one. The clients of the company are mostly the USA and European manufacturers of electronic devices. The company started implementation of Lean production in 2008 and had ten years of experience in the application of Lean methods. The company is publicly known for its achievement in Leanness.

The narrative strategy (Pentalnd, 1999, Langley, 1999) was employed to uncover the sequence of becoming Lean. Model of narrative proposed by Pentland (1999) was used as a guiding framework. In this model, narratives are characterized by five properties: a sequence of events, focal actors, narrative voice, an evaluative frame of reference, and context.

Data collection. Narrative interviews, non-participant observation, and archival documents analysis were used to collect data in the company. In total, we conducted 15 interviews lasting from 30 to 90 minutes. The interviews were conducted with employees responsible for coordination of Lean production, production, sales, and purchasing. The respondents were theoretically sampled to acquire their experience about internal, supplier-related, customer-related Lean methods. The Interviews were fashioned in narrative style prompting informants for narrating their story (Kvale and Brinkman, 2009). Interviews were transcribed and coded for analysis. The non-participant observation was conducted during visits to the site. The company also provided us with artifacts of Leanness: documents, and records, slides, etc. which were extensively used during analysis.

Data analysis. The coding for a sequence of events took center stage in our data analysis. The sequence of events related to the introduction, usage, and enhancement of each method of Lean production was coded. The timeline of events regarding each method was constructed.

After the timeline of introduction and diffusion of the Lean production methods was constructed, the affordances of the Lean production methods were coded. The affordance is an effect of an employed method for organizing. The coding proceeded through identification of first-order concepts through coding, second-order constructs (through abstraction) and theoretical constructs (though theorization) (Gioia et al., 2013) considering the timeline of events. Second order constructs were grouped into theoretical themes. Constant comparison and a possibility to complement the study with additional data provided us with a perfect setting for theorizing until theoretical saturation was achieved. At the same time, the careful attention was devoted to focal actors, narrative voice, an evaluative frame of reference, and context of the events leading to Leanness. In the next section, results of the empirical research are presented.

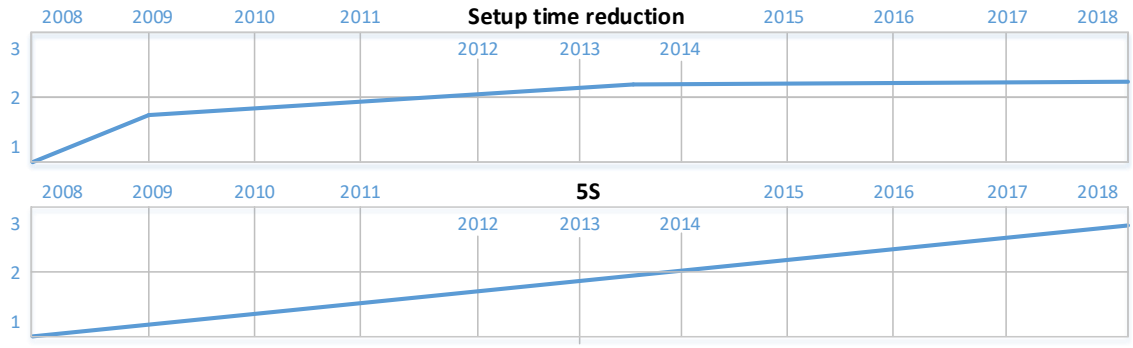
Results

Reduction of setup time of surface mount assembly lines used for the production of printed circuit boards was the primary motivation to adopt Lean production:

> "Because it is just a substantial investment<…>and the hour on that line's price is probably the most expensive of all processes. And every downtime to this is money for a huge company."… "This downtime was probably about, in various ways, sometimes even an hour and a half. It takes so much time to go from one product to another. This is money, and it was decided that something needs to be done to reduce that time."

The external consultants were hired to help to reduce setup time of surface mount assembly lines. Many practices of Lean production were introduced during two years. Later PCB Electronics assigned Quality and Lean manager as responsible for coordination of Lean production practices. Since that time, the Quality and Lean manager coordinate the efforts of Lean production occasionally involving external consultants for guidance.

Setup Time reduction, 5S, Daily Management System, Total Productive Maintenance were introduced at the very beginning. These practices were bundled to reduce setup time of surface mount assembly lines. Later, a grouping of products based on customers product families was established. The experimental U-cell was established. One-peace-flow approach was used in the U-cell. The production was pulled in the cell. PCB Electronics used the contingent approach on U-cells creating them only for products that are manufactured in large quantities or for products that require complicated assembly process. Finally, Kaizen Improvement Teams, Value Stream Mapping were introduced.



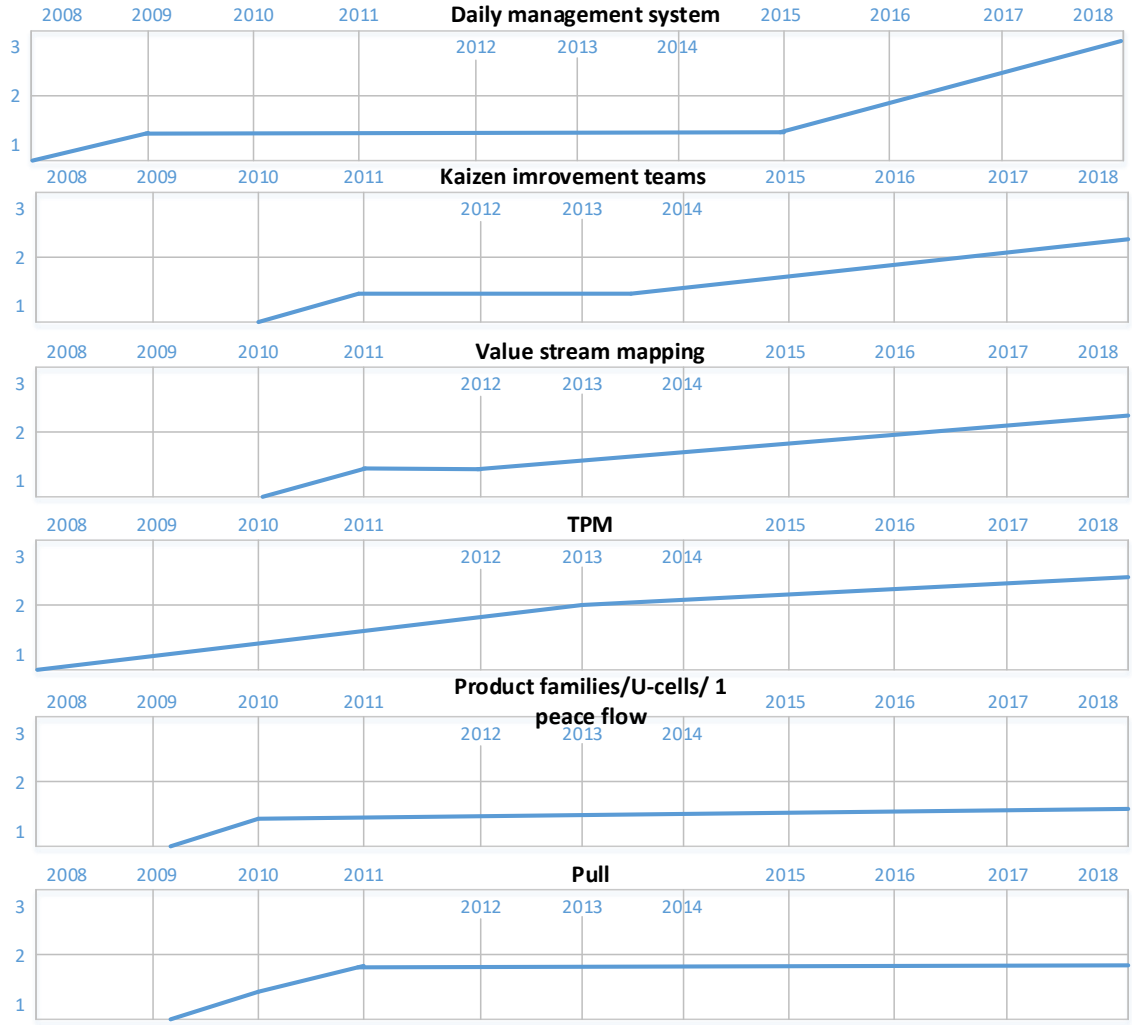


Figure 3 – Timeline of dynamics of Lean production methods and the extent of used potential

The introduction time of the particular method is vital for studying the sequence of Lean production. However, the time of an introduction does not inform on a dynamics of diffusion of the method. Usually, the practice is introduced in small scale. It is important whether the practice is captured and perpetuated by the company. For example, the PCB Electronics introduced Daily Management System in 2008. One board was introduced as part of daily meetings. A dozen of participants gathered at the board each day. The company was using a single board for six years. In 2015 PCB Electronics introduced 34 boards in every department of production and administration. The meetings were divided into three levels based on the level of employs. The meeting became structured: the particular information, indicators ought to be discussed during meetings. Consequently, the extent of the potential of Daily Management System method highly increased.

The extent of used potential is important aspect of usage of practices of Lean and it is indicated as high (3), medium (2) and low (1) in Figure 3. The used extent of potential of 5S, Daily Management System and Total Preventive Maintenance is high in the PCB Electronics. On the contrary, the extent a used potential of Statistical Process Control is extremely low, so it is not mentioned in the timeline. The extent of used potential of other methods is medium. However, the extent of used potential of the practice is a dynamic, not static, concept. The informants tend to emphasize not an introduction, but diffusion and routinization of the practice are challenging. The degradation of the of a practice of Lean production hasn't been observed in the PCB Electronics. However, the informants

emphasize that continuous support of Lean coordinators is still necessary for routine use of the practices. For example, the order of workplaces and manufacturing zones established using insights from 5S has to be continuously supported by audits of workplaces and zones.

Bundling of the methods was observed in PCB Electronics. The initial objective to reduce a setup time of surface mount assembly lines was achieved using SMED simultaneously with 5S, Daily Management System, Total Productive Maintenance. PCB Electronics started by rethinking workplaces responsible for changeovers of assembly lines using the 5S method. Later SMED heuristics were applied. The results of setup time reduction efforts were amplified by establishing maintenance of lines using TPM techniques. The board where engineers and operators could discuss on a daily basis their progress and problems their efforts was established.

Discussion

In order to propose a process model of becoming Lean, it is necessary to be aware not only about the time of introduction of the practices of Lean production but dynamics of diffusion of the practice, the extent of a used potential of the practice and bundling of the practices. The attention to these dimensions of the sequence of events leading to Leanness of PCB Electronics allows us to argue for a process model of becoming Lean.

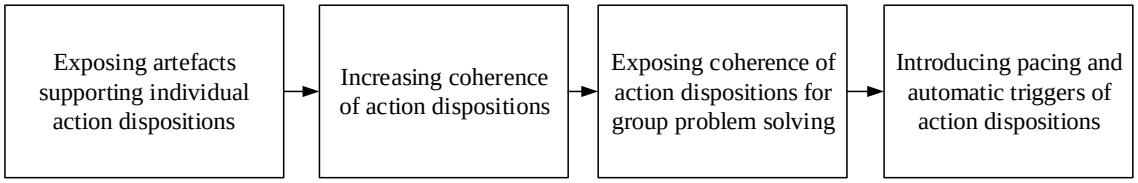


Figure 4 – A process model of becoming Lean

The pattern behind the events related to introduction and diffusion of practices of Lean production could be summarized by four stages provided in Figure 4. It is proposed that four sequential stages could explain the process of becoming Lean: a) exposing artefacts supporting individual action dispositions, b) increasing coherence of action dispositions, c) exposing coherence of action dispositions for group problem solving, and d) introducing pacing and automatic triggers of action dispositions. Drawing on theory of routines, a term action dispositions is used to denote traits, habits, or even skills (Birnholtz et al., 2007).

The goal of the first stage in becoming Lean is to make aware of individual task-related action dispositions disposition, the relation of action dispositions and artifacts and external environment. The action dispositions through repetition become unquestionable. At this stage, the relationship of action dispositions with artifacts and environment become contrasted with a logic of rationality. The first stage in the sequence of becoming Lean is enacted through practices of 5S, Visual Management, and in part with Daily Management System and Standard Work. 5S practices increase awareness of individual action dispositions in the workplace. The individual action dispositions, which are unquestionable because of repetition, become exposed.

The objective of the second stage is to increase the coherence of individual action dispositions into a concerted flow. During this stage, the coherence of individual action dispositions is increased binding them into a fast flow. To improve the coherence, products are grouped into families with similar processing requirements. If possible, U-cells are established allowing employees themselves to take control of flow connecting

and balancing the flow of action dispositions. Setup Time Reduction and Total Productive Maintenance allow avoiding the halting of a stream of concerted action dispositions

The second stage in the sequence of becoming Lean is enacted through practices of Grouping of products into families based on processing similarities or customers, U-cells, Setup Time Reduction, and Total Productive Maintenance. The action dispositions are stored in procedural memory which is difficult to articulate (Cohen and Backdayan, 1997). Specific methods are employed to make a procedural memory of individuals available to problems solving teams. The third stage in the sequence of becoming Lean is enacted through practices of Kaizen Teams, Value Stream Mapping, Gemba.

The objective of the fourth stage of becoming Lean is to introduce pacing and automatic of individual action dispositions and inter-organizational routines. During this stage, the automatic triggers, such as Kanban or One-peace-flow are introduced to link individual action dispositions automatically. The organizational routines are connected through such tools as a change of information on demand, delivery problems, supplier managed inventory. The fourth stage in the sequence of becoming Lean is enacted through practices of Pull, JIT Delivery by Suppliers, Involvement of Customers and in part by U-cells.

Conclusions

The inductive research based on a narrative strategy of a single organization that is adept in Lean production was employed to reveal the process of becoming Lean. The study showed the timeline of the introduction of Len production methods in the organization. The timeline was complemented with the analysis of the diffusion of the methods, the bundling of methods and evaluation of the extent of a used potential of each method.
Drawing on the theory of routines, it was proposed that four sequential stages could explain the process of becoming Lean: a) exposing artefacts supporting individual action dispositions, b) increasing coherence of action dispositions, c) exposing coherence of action dispositions for group problem solving, and d) introducing pacing and automatic triggers of action dispositions.

The research contributes to studies of Lean production in several ways. It sheds light on a question if practices of Lean production should be adopted sequentially or in parallel. The results of the research support proposition that there is a sequence of becoming Lean. The results provide more nuanced analysis of analysis of events leading to Leanness. The focus on the point of introduction of methods of Lean production is not sufficient. It is argued that it is important to complement to dynamics of diffusion of the practices of Lean production, the extent of a used potential of practices and bundling of practices.

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