Defining lean production: some conceptual and practical issues

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Abstract
Purpose – The purpose of this paper is to investigate the definition of lean production and the methods and goals associated with the concept as well as how it differs from other popular management concepts.

Design/methodology/approach – The paper is based on a review of the contemporary literature on lean production, both journal articles and books.

Findings – It is shown in the paper that there is no consensus on a definition of lean production between the examined authors. The authors also seem to have different opinions on which characteristics should be associated with the concept. Overall it can be concluded that lean production is not clearly defined in the reviewed literature. This divergence can cause some confusion on a theoretical level, but is probably more problematic on a practical level when organizations aim to implement the concept. This paper argues that it is important for an organization to acknowledge the different variations, and to raise the awareness of the input in the implementation process. It is further argued that the organization should not accept any random variant of lean, but make active choices and adapt the concept to suit the organization’s needs. Through this process of adaptation, the organization will be able to increase the odds of performing a predictable and successful implementation.

Originality/value – This paper provides a critical perspective on the discourse surrounding lean production, and gives an input to the discussion of the implementation of management models.

Keywords Lean production, Total quality management

Paper type Conceptual paper

Introduction
When initiating research concerning the concept of lean production (LP) one line of questions naturally comes to mind: “What is lean? How is lean defined? How does lean relate to other management concepts? What does lean have in common with other management concepts? What discriminates lean from other management concepts?”

Seeking answers to these questions, will lead to the realization that they are exceedingly hard to find. It seems logical that a management concept as popular as lean should have a clear and concise definition. Much disappointingly, the definition of lean production is highly elusive. Some authors have made attempts to define the concept (e.g. Lewis, 2000; Hines et al., 2004; Shah and Ward, 2007), while others have raised the question of whether the concept is clearly defined (see Dahlgaard and Dahlgaard-Park, 2006; Engström et al., 1996; Lewis, 2000).

A justified question is whether the convergent validity of lean actually makes any difference – does it matter how we define lean? There are various opinions on the effects of this.

The absence of a clear definition has a number of consequences for practitioners seeking to implement lean as well as researchers trying to capture the essence of the
concept. These issues have been addressed by a number of researchers. The lack of a definition will lead to communication difficulties (Dale and Plunkett, 1991 in Boaden, 1997). It will complicate education on the subject (Boaden, 1997). Researching the subject will be difficult (Godfrey et al., 1997; Parker, 2003) – although Boaden (1997) states that this is not essential. There will also be difficulties in defining overall goals of the concept (Andersson et al., 2006).

Parker (2003) states that the multitude of interpretations on what lean really is makes it harder to make claims towards the effects of lean, thus increasing the requirements that researchers specify exactly what they are researching. Karlsson and Åhlström (1996) point out that the lack of a precise definition also will lead to difficulties in determining whether changes made in an organization are consistent with LP or not, and consequently difficulties in evaluating the effectiveness of the concept itself.

**Purpose of the article**
The main purpose of this article is to give a presentation of what lean production is. This will be done through a review of contemporary literature on lean and summary of practices associated with lean as well as the stated purpose of the concept. Based on this, an evaluation of the construct validity of lean will be made.

The paper will conclude with a discussion of the practical implications of the construct validity of lean.

**Research approach**
Hackman and Wageman (1995) reviewed the TQM concept and raised the question of “whether there really is such a thing as TQM or whether it has become mainly a banner under which a potpourri of essentially unrelated organizational changes are undertaken”. This is a valid question for any construct similar to TQM, and the concept of lean production is no exception. Following the reasoning of Hackman and Wageman, this question calls for the evaluation of the concept’s convergent and discriminant validity. Hackman and Wageman (1995) describe the two kinds of validity as follows:

Convergent validity reflects the degree to which [different] versions [of the concept] [...] share a common set of assumptions and prescriptions. [...] Discriminant validity refers to the degree to which [the concept] can be reliably distinguished from other strategies for organizational improvement (Hackman and Wageman, 1995).

In other words, the discriminant validity tells us whether or not a concept carries any news value compared to other existing concepts, whereas the convergent validity, strictly speaking, tells us whether or not the concept itself really exists.

For this article, the two major citation databases ISI and Scopus have been searched for articles containing the terms “lean production” or “lean manufacturing” in the topic, abstract or keywords. The 20 most cited articles from each database were selected for further study.

Through reading these and other articles on the subject, the most influential books were identified. This list was verified through using the citation analysis software “publish or perish”.
The reviewed literature will be compared by listing the characteristics of lean presented by each author. The idea is that a method, tool or goal that is central to lean will be mentioned by every author on the topic. The purpose or goal of lean should logically be the same for all authors. Concurrence among the authors will signify a high convergent validity. If lean passes this convergent validity criterion, an evaluation of the discriminant validity can be made, based on a comparison with TQM. Hackman and Wageman (1995) concluded that TQM passed the tests of both convergent and discriminant validity, making it a good concept to compare against lean production.

**Literature review**

The two database searches produced a total of 37 articles (see Appendix), of which 12 of them contained presentations of techniques and/or overall goals associated with LP, thus contributing to a conceptual discussion.


The publications by the Lean Enterprise Institute (Rother and Shook, 1998; Jones and Womack, 2002; Smalley, 2004) are very specific on certain tools (mainly value stream mapping), and were not deemed suitable for a conceptual discussion about lean in general.

**An overview of lean characteristics**

Table I is a presentation of the most frequently mentioned characteristics of lean in the reviewed books. Characteristics that have been discussed by less than three authors have been excluded from the presentation. The characteristics in the table are sorted based on frequency of discussion in the reviewed literature.

Looking at the table reveals some interesting aspects about the ideas surrounding lean. The only two characteristics that all authors discuss are “setup time reduction” and “continuous improvement”, indicating that these are central to the concept. On the condition that pull production can be seen as a special case of just-in-time production, all authors lift this characteristic as well. Failure prevention (*poka yoke*) and production leveling (*heijunka*) also seem to be central characteristics of lean production.

**Analysis**

**Convergent validity of lean**

The characteristics listed in Table I have some relation to one another, motivating an affinity analysis. One way of grouping these characteristics is presented in Table II.

Through grouping the characteristics a more homogeneous image of the lean characteristics arises. For all but three of the groups all authors have discussed at least
Goal

<table>
<thead>
<tr>
<th>Make products with fewer defects to precise customer desires (Womack and Jones and Womack et al.)</th>
<th>One-piece flow</th>
<th>Reduce waste and improve value</th>
<th>Customer focus (high quality, low cost, short time)</th>
<th>Robust production operation</th>
<th>Cost reduction</th>
<th>Eliminate waste and reduce costs</th>
<th>Improve quality and productivity</th>
<th>Cost reduction through waste elimination</th>
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<tbody>
<tr>
<td>Kaizen/continuous improvement</td>
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<td>Setup time reduction</td>
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<td>Just in time production</td>
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<td>Kanban/pull system</td>
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<td>Poka yoke</td>
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<td>Production leveling (Heijunka)</td>
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<td>Standardized work</td>
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<td>Visual control and management</td>
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<td>Small lot production</td>
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<td>Time/work studies</td>
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<td>Waste elimination</td>
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<td>Inventory reduction</td>
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<td>Supplier involvement</td>
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<td>TPM/preventive maintenance</td>
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<td>Autonomation (Jidoka)</td>
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Table I. A presentation of characteristics associated with lean production. The characteristics are sorted by accumulated frequency.
| Make products with fewer defects to precise customer desires (Womack and Jones and Womack et al.) | One-piece flow | Reduce waste and improve value | Customer focus (high quality, low cost, short time) | Robust production operation | Cost reduction | Eliminate waste and reduce costs | Improve quality and productivity | Cost reduction through waste elimination |
|---|---|---|---|---|---|---|---|---|---|
| Statistical quality control (SQC) | x | x | x | NO! | x | x | x | x |
| Teamwork | x | x | x | x | x | x | x |
| Work force reduction | x | x | x | x | x | x | x |
| 100% inspection | x | x | x | x | x | x | x |
| Layout adjustments | x | x | x | x | x | x | x |
| Policy deployment (Hoshin kanri) | x | x | x | x | x | x | x |
| Improvement circles | x | x | x | x | x | x | x |
| Root cause analysis (5 why) | x | x | x | x | x | x | x |
| Value stream mapping/flowcharting | x | x | x | x | x | x | x |
| Education/cross training (OJT) | x | x | x | x | x | x | x |
| Employee involvement | x | x | x | x | x | x | x |
| Lead time reduction | x | x | x | x | x | x | x |
| Multi-manning | x | x | x | x | x | x | x |
| Process synchronization | x | x | x | x | x | x | x |
| Cellular manufacturing | x | x | x | x | x | x | x |

Table 1. Defining Lean production
one of the characteristics in the group. In the group labeled as human resource management none of the characteristics are discussed by authors Bicheno and Shingo. The authors Ohno and Schonberger have not discussed any of the characteristics in the group labeled as supply chain management. Furthermore, the bundled techniques have slightly lower figures. This indicates that the two groups human relations management and supply chain management are not definable characteristics of lean, contrary to the findings of Shah and Ward (2003). However, the scores are quite high, indicating that they are important (although not vital) parts of the lean concept.

Looking at the goals presented by the reviewed authors (Table I) raises some questions towards the convergent validity of lean. The general opinion that the purpose of lean is to reduce waste does not seem to hold, although some authors (Bicheno, 2004; Monden, 1998; Shingo, 1984) argue for this. As discussed above there are two main traditions of lean; “toolbox lean” and “lean thinking”. This is also evident...
in the differences of goals in the reviewed literature. Generally speaking, there are two different types of goals, internally focused (Liker, 2004; Feld, 2001; Ohno, 1988; Monden, 1998; Schonberger, 1982; Shingo, 1984) and externally focused (Womack et al., 1990; Womack and Jones, 2003; Bicheno, 2004; Dennis, 2002; Schonberger, 1982). One could argue that the differences in formulation of purpose are very small thus making it a minor issue. However, an internally focused cost reduction initiative will differ substantially from an externally focused initiative to improve customer satisfaction.

The division of lean production in the two parts discussed above has led to discussions of which one is more correct. A common statement is that “lean is more than a set of tools” (Bicheno, 2004), arguing for a more philosophical approach to lean. However, there is also another position that argues for a more practical and project based approach to lean and that “lean is a collection of waste reduction tools”. This kind of statement is hard to find explicitly in academic texts, but very common among certain practitioners.

Neither of the positions are more correct than the other, since lean exists at both levels, having both strategic and operational dimensions (Hines et al., 2004). In addition, lean can be seen as having both a philosophical as well as a practical orientation (Shah and Ward, 2007).

Through adapting and combining the four approaches to lean suggested by Hines et al. (2004) and Shah and Ward (2007) respectively, lean can be characterized in four different ways. The terms practical and philosophical are substituted by the terms performative and ostensive. The terms operational and strategic are substituted by the terms discrete and continuous.

In Table III four different approaches to lean production are presented. The term ostensive signifies a shift of focus from general philosophy towards issues that can only be defined by examples, whereas performative and practical focus on the things that are done. The term discrete signifies a focus on isolated events, such as individual improvement projects using the “lean toolbox” (see Bicheno, 2004; Nicholas and Soni, 2006), or the final state of “leaness” (see Krafcik, 1988). As a contrast, the term continuous signifies a process oriented perspective, focusing on the continuous efforts; the philosophy of “lean thinking” or “the Toyota way” (see Womack and Jones, 2003; Liker, 2004) or the process of “becoming lean” (see Liker, 1998; Karlsson and Åhlström, 1996).

Although the score is not perfect, lean seems to be a reasonably consistent concept comprising just in time practices, resource reduction, improvement strategies, defects control, standardization and scientific management techniques. However, it is hard to formulate a clear definition that captures all the elements of lean and integrates the various goals in the reviewed literature. In other words, lean can be said to (barely)

<table>
<thead>
<tr>
<th>Discrete (Operational)</th>
<th>Continuous (Strategic)</th>
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<tbody>
<tr>
<td>Ostensive (Philosophical)</td>
<td>Leanness</td>
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<tr>
<td>Performative (Practical)</td>
<td>Toolbox lean</td>
</tr>
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</table>

Note: The terms in parentheses are the ones suggested by Hines et al. (2004) and Shah and Ward (2007) respectively.
pass the convergent validity test, although there is no clear agreement among the authors as to the overall purpose of the concept.

**Discriminant validity of lean**

So what is the difference between TQM and lean production? In the following section Lean and TQM are compared based on the analysis made by Hackman and Wageman (1995). The discussion is done with three different aspects; basic assumptions, change principles and interventions:

1. **Basic assumptions:**
   - **Quality.** In lean, quality does not receive the same amount of attention as in the TQM literature. The main focus in the lean literature is on just-in-time (JIT) production. JIT is assumed to decrease total cost, as well as highlight problems. This is done through reducing the resources in the system, so that buffers do not cover up the problems that arise. In the short-term perspective, the reduction of resources implies a direct reduction of cost. In the long run, the reduction and subsequent elimination of buffers is assumed to highlight the problems that exist in production, thus being a vital source of continuous improvement (e.g. Shingo, 1984; Ohno, 1988; Krafcik, 1988).
   
   A common opinion is that the purpose of lean is waste elimination. The literature review does not show support for this being the very purpose, but waste elimination is definitely an important aspect of the concept. Some authors argue that waste is reduced in order to increase the value for the customer (e.g. Dennis, 2002; Bicheno, 2004), whereas others argue that it is a strategy for reducing cost (e.g. Ohno, 1988; Monden, 1998). Reducing waste is also a significant part of TQM, but under the banner of poor-quality-costs (see Hackman and Wageman, 1995; Sörqvist, 1998). A major difference between TQM and lean in this aspect is the precision in defining waste. In the majority of the lean literature, waste or *muda* is based on the seven forms[1] defined by Ohno (1988), whereas TQM has a very general definition of poor-quality-costs, including everything that could be eliminated through improvement (Sörqvist, 1998).

   - **Employees and the quality of their work.** One major critique of the lean concept is that it is generally weak concerning the employees” perspective. The proponents of lean production usually have a strong instrumental and managerial perspective, discussing employees in terms of components in the production system (see Kamata, 1982; Berggren, 1992, 1993).

   The extensive discussion about *jidoka* and *poka yoke* in the lean literature suggests that employees cannot be trusted to produce good quality, thus creating a necessity for removing the possibility of human error from the system.

   - **Organizations as systems.** One thing that lean and TQM have in common is seeing the organization as a system (see Womack and Jones, 2003; Bicheno, 2004). But there is a slight difference in perspective between the two concepts. Whereas TQM has a strong focus on the internal structure and integration of departments within the organization, lean stresses a supply chain perspective, seeing the internal production operations as a part of a
value stream from the sub-suppliers to the end customer (e.g. Rother and Shook, 1998; Jones and Womack, 2002).

- **Quality is the responsibility of senior management.** This is another perspective that lean and TQM share, but again with some differences. TQM-managers should create structures that support the employees in producing products of high quality (Deming, 1986; Hackman and Wageman, 1995). The idea is the same in lean, but the rationale for doing this seems to be centered around eliminating the human factor from the system through *jidoka* and *poka yoke*. Using the terminology of McGregor, one could argue that TQM seems to be based on theory Y, whereas lean seems to be based on theory X (see Ezzamel et al., 2001).

(2) Change principles:

- **Focus on processes.** Within the lean concept the term value stream is usually preferred (Womack and Jones, 2003). The term process is usually used at a lower level of abstraction that TQM theorists would call sub-processes or activities (see Riley, 1998). The conception that management should analyze and improve the processes and train the employees is also shared by the two concepts.

- **Management by fact.** The literature on lean does not really stress the management by facts explicitly. However, this is implicit in the description of lean practices, many of which are analytical tools designed to help achieve JIT production. Although this is a shared perspective between lean and TQM, there is a difference. Within TQM the analysis of variability through using statistical tools is a central concept (Hackman and Wageman, 1995). In the lean tradition, this is not seen as equally important. In fact, some authors argue against the use of statistical tools for analyzing production performance, recommending alternative tools such as increased inspection and visualization of problems (e.g. Dennis, 2002; Liker, 2004).

- **Learning and continuous improvement.** In the words of Hackman and Wageman (1995) TQM is “pro-learning, with a vengeance” (p. 330). The learning aspects are not emphasized as much in literature on lean. As discussed above, the lean literature is generally weaker on the human behavior side, focusing more on instrumental techniques for improving system performance. There is a clear focus on continuous improvement, which implies that some form of learning is required. However, the question is who is learning. TQM is focused on stimulating creativity and individual efforts for improvement (Hackman and Wageman, 1995), whereas lean places strong emphasis on the standardization of work and collective learning (Niepce and Molleman, 1998; Thompson and Wallace, 1996).

(3) Interventions:

- **Analysis of customer requirements.** Customer focus is one of the hallmarks of TQM, where every improvement should be based on an investigation of the customer’s requirements, whether the customer is internal or external. The lean concept does not emphasize customer interests. Some authors argue that the very purpose of lean is to please the customer (e.g. Dennis, 2002), but
methods for analyzing customer requirements are extremely rare in the reviewed literature, suggesting this is not a typical lean intervention.

- **Supplier partnerships.** The suppliers are seen as important in both lean and TQM. Both concept stress the point that long term partnerships should be made with suppliers and that improvements should be done in collaboration with them. Although this matter is not discussed by all authors in this analysis, the majority of them do (see Table I).

- **Improvement teams.** Quality circles have a central role in much of the TQM literature, and can be put to use in problem solving or improvement activities. In the lean literature, improvement teams are explicitly discussed by just about half of the reviewed authors. However, they are often implicated in discussions about improvement activities.

- **Scientific methods for performance measurement and improvement.** Both TQM and lean employ various scientific methods for analysis and evaluation of performance. However, these methods differ significantly, and the tools associated with one concept are generally not mentioned in literature on the other one. The purpose of measurements also differs. In TQM measurements are done in order to identify problems and to document improvement, whereas lean theorists argue that measurements should be made for planning and synchronization purposes; e.g. for setting production rate (see Ohno, 1988; Bicheno, 2004).

- **Process management techniques.** As discussed above, the term process is used in slightly different ways by authors on TQM and lean. In the lean literature, different techniques are presented for both overall process level and individual activities. At an organizational level value stream mapping (VSM) can be used for highlighting several kinds of problems in the processes (Rother and Shook, 1998). At a more operational level, different time/work study techniques are discussed, e.g. so-called spaghetti charts (e.g. Bicheno, 2004).

Lean and TQM – same but different

At a philosophical level, lean and TQM have many ideas in common, in particular concerning continuous improvement and the systems perspective. However, at a more operational level, the two concepts differ significantly. The fundamental values of the two concepts are also quite different, especially regarding humanistic values.

Conclusions

There is no agreed upon definition of lean that could be found in the reviewed literature, and the formulations of the overall purpose of the concept are divergent. Discomforting as this may seem for lean proponents, there seems to be quite good agreement on the characteristics that define the concept, leading to the conclusion that the concept is defined in operational terms alone. Formulating a definition that captures all the dimensions of lean is a formidable challenge.

According to Hines et al. (2004) lean is constantly evolving, implying that any “definition” of the concept will only be a “still image” of a moving target, only being valid in a certain point in time. This may be an explanation to the apparent differences
between authors on the subject. Based on this, it is hard not to raise the question of whether a consistent definition of lean is possible to produce. Also, one can question whether a definition will be useful at all, regarding the ever changing nature of the type of constructs that management concepts such as TQM and lean are. Nonetheless, attempts have been made in this article to present the essentials of lean production and convey its most salient philosophical elements, hopefully clearing up some of the confusion that surrounds the concept.

Lean is also significantly different from its closest relative TQM, leading to the conclusion that lean is a management concept of its own. The conclusion from Shah and Ward (2003) that TQM and other bundles are parts of lean is not supported by this study.

Womack et al. (1990) argue that the lean principles are applicable to any industry. If this is correct, then the Japanese should logically have distributed the knowledge of these principles throughout all domestic Japanese industry. This does not seem to be the case. The only “true” lean producers in Japan are confined to the automobile industry, represented by, e.g. Toyota, Honda and Mazda, whereas other areas of industry are performing at the same level as (or worse than) western competitors[2]. This was pointed out more than 20 years ago by Keys and Miller (1984), implying that the principles constituting LP have not received any wide-spread attention outside the auto-industry. Cooney (2002) argues that the possibility to become “lean” (through JIT in particular) is highly dependent upon business conditions that are not always met, thus limiting the “universality” of the concept.

When embarking on a journey towards lean, it is important to acknowledge the different perspectives that the concept comprises. Raising the awareness of these differences may help make the message clearer and avoid conflicting opinions on which concept the organization is implementing. The obvious fallibility of the claimed universality of lean should help motivate an adaptational approach to implementing the concept, aiming to find a production concept that agrees with the contextual factors and previous production practices that exist within the organization. Making active choices with regard to values and techniques should increase the odds of succeeding in the improvement of the production system.

Notes
1. Transportation, Inventory, Motion, Waiting, Overproduction, Overprocessing, Defects.
2. Shu Yamada, University of Tsukuba – Seminar at Linköping University, 2007.

References


Jones, D.T. and Womack, J.P. (2002), *Seeing the Whole*, Lean Enterprise Institute, Brookline, MA.


Smalley, A. (2004), *Creating Level Pull*, Lean Enterprise Institute, Brookline, MA.


Defining lean production


Further reading


Appendix

The works shown are the result of the literature search and the details may be found in the reference list:

- Cusumano (1994).
- Cutchergershenfeld *et al.* (1994).
- Dankbaar (1997).
- Delbridge *et al.* (2000).
- Dyer (1994).
- Karlsson and Åhlström (1997).
- King and Lenox (2001).
- MacDuffie and Helper (1997).
- Mason-Jones and Towill (1997).
- Mumford (1994).
- Oliver *et al.* (1996).
Shaiken et al. (1997).
Thompson and Wallace (1996).
Williams et al. (1992).
Womack and Jones (1994).

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Jostein Pettersen has a MSc with specialization in Quality Management. He is currently a PhD candidate at the Department of Quality Technology and Management as well as the HELIX VINN Excellence Centre at Linköping University. His research is directed towards the dissemination and implementation of lean production. Jostein Pettersen can be contacted at: jostein.pettersen@liu.se