Benchmarking

Lean 2020

The Future of Operational Excellence

General Report
Preface

As new digital technologies enter the market accompanied by huge expectations of achievable performance gains, traditional manufacturing paradigms are challenged in different ways. In the light of newly available approaches which ask for reconsideration of traditional production management concepts, the already complex task of managing production in high-wage countries is getting even more challenging.

Lean Production is one of the most influential manufacturing paradigms of recent times and according to several scholars, it will continue to be the standard manufacturing mode of the 21st century. But how do the aspired digitally enabled performance gains and the human-centric Lean paradigm fit together? We have examined this and other questions as part of this benchmarking study.

Over the course of the past 25 years Lean Production has enabled companies to meet customer demands in terms of quality and competitive costs. However, as customer expectations are always increasing companies need to develop new approaches to reach the next stage of operational excellence.

To shed a light on how to reach this next stage, the Institute of Technology Management at the University of St. Gallen has launched this benchmarking study titled “Lean 2020 - The Future of Operational Excellence”.

The study focuses on both the status quo and on pathways to the next stage of Lean. In this context we analyze organizational, cultural and technical aspects of Lean Production and investigate how companies identify value along the value stream. Furthermore, the study discusses trends, challenges and opportunities for Lean Production based on insights from companies from a broad range of industries on their quest for operational improvements.

With 75 participants from 14 industries, this cross-industry study contributes to a better understanding of the status quo and identifies challenges, opportunities and trends for the next stage of Lean.

With kind regards,

Prof. Dr. Thomas Friedli
Director Institute of Technology Management
Executive Summary

Benchmarking Study Key Facts

### 75 Participants
- **26%** small and medium-sized enterprises (SMEs) with less than 250 employees
- **74%** large companies with more than 250 up to 50,000 employees
- **14 Industries** are represented in the sample

### Revenue
- **51%** of all participants generate more than 250 million EUR in revenue
- **49%** of all participants generate less than 250 million EUR in revenue

### Company Type
- **68%** of all participants are in Industrial Goods (B2B) business
- **31%** of all participants are in Consumer Goods (B2C)

### Lean Experience
- **50%** of all participants have five or more years of Lean experience
- **25%** of all participants have even more than ten years of Lean experience

Benchmarking Study Key Findings

I. Without producing customer value reducing waste is not Lean.

II. Cost reduction should neither be the Lean objective nor the Lean method, it should be the Lean result.

III. Digitalization can pave the way for better pulling together across departmental and organizational boundaries.

IV. Pull and flexibility can go hand in hand.

V. Building on Lean is and will increasingly be critical to sustain competitiveness.

VI. Lean and Digitalization are mutually beneficial.

VII. Big Data is seen as a key enabler for improving Lean Production.

VIII. Companies report a large backlog in terms of IT-infrastructure and data analysis know-how of employees.
# Chapter Overview

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<tr>
<th>Introduction</th>
<th>Chapter 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Page 3-10</td>
<td>The first chapter presents background information on the study together with information on the sample such as represented industries, company size as well as order fulfilment strategy and type of business (B2B, B2C, B2G)</td>
</tr>
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<th>Lean Management Status Quo</th>
<th>Chapter 2</th>
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<td>Chapter two sets forth the status quo for Lean Production based on a cross-industry benchmarking sample. Based on an analysis of organizational and cultural factors and the value stream this chapter discusses current Lean objectives, past achievements and current capabilities.</td>
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<tr>
<th>Lean Management The Next Stage</th>
<th>Chapter 3</th>
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<tr>
<td>Page 22-40</td>
<td>The third chapter discusses trends in Lean Management especially with regards to Digitalization. The study evaluates challenges and opportunities that might arise from the integration of digital technologies into Lean systems. A special focus is set on the utilization of manufacturing and customer data to improve operations. Furthermore, key enablers for the next stage of Lean are discussed.</td>
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The benchmarking followed an established and proven process. First, the topics of major emphasis that are to be investigated in the benchmarking study were defined. Second, a benchmarking questionnaire to collect data on those focus topics was developed. Out of the 75 companies, which completed the survey, 10 potential successful practice companies were identified.

A group of industry experts then selected four companies based on anonymized case studies, which were then awarded with the Lean2020 Successful Practice Award. Learnings from the entire benchmarking process feed into this benchmarking report and thus provide an overview of the status quo and an outlook on the next stage of Lean.

The four selected successful practice companies that were awarded with the Lean2020 Successful Practice Award are:

1. Henkel AG & Co. KGaA
2. LivaNova Deutschland GmbH
3. Swisscom AG
4. thyssenkrupp Presta AG
Evaluation Method

The graphs and conclusions in this report are all based on the outcome of the survey, which was conducted in 2017. In a first step, the data was collected and validated. Incomplete answers were removed. In a second phase, this data was analyzed, images and figures were created and conclusions drawn.

To facilitate the identification of differences between Leading Companies and other companies, the overall sample was divided into the following groups:

- All Companies
- Leading Companies
- Follower
- Experience < 5 years

The group "All Companies" is consistent with the overall sample, hence contains the answers of all 75 participants. We refer to this group when we describe the situation in general.

The group "Leading Companies" contains 20 companies that are characterized by an overall high level of maturity in regards to Lean Management but also concerning the integration of new digital technologies. We use this group to show, what is currently possible and already realized in mature companies.

The group "Follower" consists of all sites except the sites of the group Leading Companies. Consequently, the Follower group has in general a lower level of maturity. The comparison of Leading Companies and Follower allows to identify improvement opportunities.

As Lean is a philosophy that needs often several years to be fully engrained into a company's way of working, we felt that it is worthwhile to take a specific look at those companies that have just started with Lean within the last five years. Therefore, the group “Experience < 5” years summarizes the answers of all companies with less than five years Lean experience.
For this study, both the status quo and the next stage of Lean depict major areas of interest. Our Lean understanding builds upon the five Lean principles which are highlighted in the benchmarking model below. The structured model also represents the basis for the questionnaire that was used to collect the study data.

The model is structured into four chapters and builds upon the five Lean principles (1) Definition of Customer Value, (2) Identification of Value Stream, (3) Flow, (4) Pull and (5) Seek Perfection. Each of the principles is addressed by specific sections of the questionnaire in order to allow a holistic and sound Lean assessment.

All four elements of the study model were taken into account for the selection of Leading Companies. Thereby companies were identified that today not only show high Lean maturity level but that are also well positioned for Lean in an increasingly dynamic and digitalized environment.

Study structure “Lean 2020 – the future of operational excellence”:
General Information

The following section shows characterizing elements of the participating companies. The following pages then provide insights into the composition of the sample regarding industry, size, product type, revenue and Lean experience.

Participating companies originate from a wide range of industries (Figure 1). More than one fifth of all participants belong to the mechanical engineering sector. Furthermore, production and processing of metal goods, manufacturing of electrical equipment and medical devices constitute a significant percentage of the sample. 10% of the questioned companies were not able to classify themselves on basis of the given industry structure and stated to be producer of other goods.

![Figure 1: Industries of study participants](image)

In Figure 2 the different company sizes are listed according to their frequency in the sample. About a fourth of the questioned companies have more than 5000 employees, while also a fourth of the participants have less than 250 employees. A share of 13% of the participants are global players and employ more than 10000 people. Overall, it can be seen that the survey covers a broad range of companies from various sizes that rely on Lean principles to organize their production.
As shown in Figure 3, a majority of 68% produce industrial commodities. Business to Business (B2B) refers to commercial transactions between companies. Producers of goods directly designated to the end customer (Business to Customer – B2C) constitute 31% of the sample. A small minority of 1% stated to produce commodities for public authorities (B2G).

The analysis of order processing concepts reveals a heterogeneous picture. Make-to-order has the highest popularity (38%) among the participating companies according to Figure 4. About every third firm applies the make-to-stock concept and produces independently of orders. 16% apply the assemble-to-order concept. Hereby, pre-manufactured components are assembled after a customer order. The approach of engineer-to-order in which goods are designed, engineered and manufactured after the customer has ordered, are applied by 14% of all companies.
Lean Management – Status Quo

What companies aim to achieve with Lean Management …

There are plentiful definitions on what Lean Management is and what it is not. In order to understand what Lean Management constitutes in today’s business environment, it is worth looking at the objectives that companies aim to achieve with their Lean activities, and how these objectives changed over the course of the past five years.

The survey results indicate that cost reduction, the one objective that Lean promoters unanimously claim should not be the focus of Lean activities, is the most aspired Lean objective (see Figure 5). And if recent changes in importance of these Lean objectives are any indication for Lean objectives of the near future, cost reduction will continue to remain on top of companies Lean priorities.

The analysis of the survey results shows, that to achieve the aspired objectives companies have planned improvements in five major areas: (1) Processes optimization (97%*). (2) Problem solving capabilities (89%*). (3) Lean culture (89%*). (4) Employee qualification (82%*). (5) Leadership (80%*). It can be highlighted that four out of these five focus areas underpin the importance of the human-centric approach, which is at the core of the Lean philosophy. The more technical improvement areas such as (6) Demand forecasting & Planning adherence (69%) and (7) Flexibility (65%) follow soon after, together with (8) Collaborative supplier relationships (54%) and (9) Identification of customer needs (53%).

*Percentage of surveyed companies, that have planned improvements in this field

Figure 5
Which goals do you aim to achieve with your Lean efforts?

n = 75
The creation of customer value at the heart of Lean activities?

The above-mentioned objectives, which the surveyed companies aim to achieve with Lean activities can be interpreted in manifold ways. One way to interpret the results is, that companies still prioritize cost reduction of internal cost over customer value generating aspects such as reduced delivery times, increased quality or shorter innovation cycles. Another way to look at it is, that companies have identified cost reduction as a lever to deliver customer value, as reduced production costs can be passed on to the customer, who only accepts the product at a certain price.

Regardless of how high the price’s contribution to customer value is, companies have plentiful improvement potential when it comes to increasing customer value. Based on this survey, only 36% of all companies state, that product and process development are closely linked in order to increase customer value (see Figure 6).

Leading Companies demonstrate a stronger focus on integrated product development (45%) as opposed to Followers and companies with less than five years of Lean experience (30%).

“
A true Lean company understands what is customer value, and continuously work towards achieving a state to be able to deliver the perfect value to its customers through a perfect value creation process which has no waste”

Dr. Thomas Scheermesser
Head of Production Process Improvement
SIG Combibloc

Figure 6
Are product and process development closely linked to increase customer value?
n = 73
Benchmarking – Lean 2020 – The Future of Operational Excellence

What Lean Management is and what it is not …

There are diverging perceptions on what Lean Management comprises. In order to understand the trajectory of the Lean evolution, we looked across industries, to identify what constitutes Lean today. As a result, we received a total of almost 70 definitions for Lean Management. Based on a text analysis of the provided definitions, performed with R studio, we identified the words most frequently used to define Lean Management. In order to account for different variations of the same word (e.g. optimize and optimization), we reduced the words to a word stem. The result are the 200 most often used word stems to describe Lean Management (see Figure 7). The total number of word counts is represented by the size of the shown word stem.

Joost Fastenrath
Head of Production of Infusion Pumps B.Braun Melsungen AG

“Lean is a philosophy to organize your work. Customer focused, employee focused with the clear target to continuously improve how you’re doing your job.”

The most frequently used terms to describe Lean emphasize the central role of three aspects of Lean: (1) Continuous Improvement, (2) reduction of waste and (3) the generation of customer value. It is worth highlighting that both word stems “process” and “product” are among the most frequently used terms. However, while an explicit process focus can be observed from frequent terms such as “process”, “activity” or “work”, the high frequency of the word stem “product” can actually be traced back to the word “production” instead of “product”.

It is worth highlighting that, while the process focus of the Lean philosophy can be traced back to modern quality management practices, Lean practitioners must also incorporate thinking in terms of product to generate customer value.
How do companies position themselves for Continuous Improvement?

Continuous Improvement is the dominating paradigm in Lean organizations. To position themselves for Continuous Improvement, manufacturing companies need to build a solid foundation for companywide lean Thinking. In addition to having an appropriate Lean culture, companies need to embed Lean strategically in their organization to align all internal and external activities with the organization’s Lean objectives. Almost 85% of companies surveyed state that Lean is a part of their corporate strategy, which reflects the strong commitment that many companies make to Lean Management in recent years.

From the study the strategic importance of Lean on management level is evident. However, the results also indicate that improvement potential exists regarding the degree of employee and supplier involvement in Lean activities (see Figure 8). While overall only a little share of the surveyed companies fully agree that employees continuously strive to reduce waste (A) respectively that they use joint improvement programs with suppliers (B), results vary across the analyzed groups. While almost every second Leading Companies fully agree to statement A only every fifth Follower does. Statement B shows a similar tendency where still 16% of Leading Companies fully agrees to the question, compared to only 6% of the Followers. The group of late Lean adopters follows for both statements A and B far behind.

“For us, Lean is a system creating transparency on goals and value creation, fostering empowerment and Continuous Improvement, which is carried by all employees and managers in our organization.”
Pull together across departmental boundaries ...

Lean Management has a more than 25-year-old history in production. However, against various efforts Lean has not yet fully gained foothold in the other company areas. While in the surveyed companies lean Thinking is well established in the areas Production and Quality, our study reveals that Lean is least established in the areas such as Marketing, Sales or Aftersales/Services (see Figure 9). For each company area, the level to which Lean is implemented varies across the groups.

In order to pull together, lean Thinking does not only need to spread into more areas of the companies. Furthermore, companies need to better align internally and ensure an effective flow of information.

The survey results indicate substantial improvement potential for both aspects, as employees are often not well equipped to fully understand the upstream and downstream tasks of their work and neither do they have access to all relevant business intelligence necessary for Continuous Improvement (Figure 10).

**Figure 9**
To what degree is Lean established in your organization?  
n = 74

**Figure 10**
To what degree do the following statements apply to you?  
n = 74
Lean achieves what is set out to be achieved ...

In the past five years the surveyed companies have made significant achievements. Major improvements have been made first and foremost with regards to cost reduction, followed by reduced delivery times, quality improvements and shorter innovation cycles (see Figure 11). Strikingly, these achievements follow the same order as the aspired Lean achievements, mentioned above in section “What companies aim to achieve with Lean Management …” (page 13). For the next stage of Lean this can as well be an encouragement to continue the Lean journey, as the results suggest, that what you aim for is what you get. Considering that Lean is still in its infancy in many company areas one can expect even more from Lean in the future.

Figure 11
What achievements have you made with regards to Lean within the last 5 years?

<table>
<thead>
<tr>
<th>No improvements</th>
<th>Major improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost reduction</td>
<td></td>
</tr>
<tr>
<td>Delivery dependability (On-time-delivery)</td>
<td></td>
</tr>
<tr>
<td>Quality improvements</td>
<td></td>
</tr>
<tr>
<td>Delivery speed</td>
<td></td>
</tr>
<tr>
<td>Shorter innovation cycles</td>
<td></td>
</tr>
</tbody>
</table>

Stephan Suess
Lean Production Specialist
LivaNova Deutschland GmbH

“Lean is a mindset of an Organisation. The aim is to achieve operational excellence in all Business functions, not only Manufacturing.”

Lean experience...

While the concept of Lean has been introduced more than 25 years ago it took companies across industries some time to adopt and to formalize Lean in their organization. While manufacturing companies were the first adopters of Lean, service companies followed a little later. By now a majority of the surveyed companies have implemented a formal Lean program. Of all participants around 50% have at least 5 years of Lean experience. Another quarter of the companies has in fact more than 10 years of Lean experience.

Figure 12
How many years of experience do you have with Lean?

<table>
<thead>
<tr>
<th>No Lean experience</th>
<th>&lt; 3 years</th>
<th>3-5 years</th>
<th>5-10 years</th>
<th>&gt;10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>0%</td>
<td>25%</td>
<td>50%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Quo vadis Lean?

Despite the great usefulness of Lean, emphasized by both researchers and practitioners, most companies have not yet mastered Lean in their organization. Despite many years of Lean experience, only every sixth company feels well prepared to master Lean in a highly volatile and globalized world. Every second respondent stated that they are either undecided or that they don’t feel prepared for Lean in the future. In general companies with less than five years Lean experience are more sceptic about their ability to master Lean in the near future, while Leading Companies in general feel more prepared (see Figure 13). The large number of undecided or less prepared companies indicate a significant uncertainty among many companies across industries, as to what “good” actually looks like and what is needed in order to get to the next stage.

Technology Scouting

The ability to sense technological trends enables companies to always be at the leading edge and to continuously reposition internal and external resources to optimally address current and upcoming challenges. Every third Leading Company has a strong focus on technology scouting in order to assess new technologies regarding technical and financial benefit. In contrast to this only every fifth company overall emphasizes technology scouting. While technology scouting is a crucial first step for a periodic re-assessment of the entire value stream, it is not enough to simply be aware of technological developments. As the survey results indicate, achieving the next stage of Lean also means finding a way to exploit new technologies without losing the Lean DNA.

Figure 13

Is your company prepared to master Lean Management in a highly volatile and globalized world?

n = 73

<table>
<thead>
<tr>
<th>Experience &lt; 5 years</th>
<th>All companies</th>
<th>Leading Companies</th>
<th>Follower</th>
</tr>
</thead>
<tbody>
<tr>
<td>not at all (- -)</td>
<td>15%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>(-)</td>
<td>32%</td>
<td>5%</td>
<td>19%</td>
</tr>
<tr>
<td>neutral (0)</td>
<td>38%</td>
<td>70%</td>
<td>42%</td>
</tr>
<tr>
<td>(+)</td>
<td>14%</td>
<td>20%</td>
<td>26%</td>
</tr>
<tr>
<td>totally prepared (++)</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
</tbody>
</table>
Lean does not always equal Flow...

Achieving a continuous flow, involving almost no interruptions and thereby eliminating waste is at the heart of Lean Thinking. However, while the survey results indicate that companies strive to implement continuous flow, only few of the surveyed companies have achieved this today (see Figure 14). The Leading Companies are top of the class with regards to Flow and show that considerable improvements are still possible. At the same time Leading Companies have a stronger emphasis on pursuing Flow, which underlines the respective importance for these companies. Another finding is that the degree to which the Pull principle is implemented across industries is not as high as one might expect, given that Pull is another key Lean principle. Considering, that around 30% of surveyed companies primarily follow a make-to-stock strategy this result does not surprise so much anymore. Similar to the before mentioned Flow implementation it is the Leading Companies that are accentuating the importance of Pull for Lean success.

Besides Flow and Pull another improvement potential concerns the periodic reassessment of the entire value chain. Since Continuous Improvement is the mantra of Lean Thinking, it is the logical next step to look beyond the shop floor and to take the entire value chain into account. However, today many of the surveyed companies are still a long way from periodic re-assessment let alone real-time monitoring of the entire value chain.

Towards Pull, Flow & Flexibility...

Companies need to keep inventory levels low, while at the same time being responsive to changing customer needs, The study results show that only one out of four is able to handle volatility in volume of more than 85% (see Figure 15 next page). A lack of Flow and Pull leads to higher inventory, which may even be beneficial for volume flexibility. However Leading companies, which show a higher level of Pull implementation, demonstrate that this can also be achieved with lower inventory.

**Figure 14**

Please indicate to what degree the following apply to you:

n = 75

- We periodically re-assess the entire value stream.
- We strive for continuous flow production, involving almost no interruptions.
- Our current manufacturing process can be described as a full continuous flow.
- Our production control is driven by a ‘Pull’ system.
- Our layout of the shop floor facilitates low inventories and fast throughput.

![Survey Results](image)

<table>
<thead>
<tr>
<th>Experience</th>
<th>All companies</th>
<th>Leading Companies</th>
<th>Follower</th>
<th>Experience &lt;5 years</th>
</tr>
</thead>
</table>
Based on the results from Leading Companies, Figure 15 shows that the implementation of Pull does not necessarily lead to lower flexibility (also see Figure 14). Instead, the results suggest that there is a pathway in Lean to achieve both a reduction of inventory levels and buffers and high flexibility.

Supplier relationships

The integration of suppliers plays a central role in Lean, which is demonstrated by Toyota in an outstanding fashion. Close supplier relationships are since Toyotas rise seen as key enablers for Lean success. Figure 16 shows how participants characterize their supplier relationships. Leading Companies seem to be one step ahead of its peers when it comes to supplier relationships. For example, Leading Companies receive deliveries on average in smaller quantities, which enables lower inventories and supports just-in-time production. Quality inspections at the supplier allows further efficiency gains compared to resource intensive quality inspections on-site. Another aspect worth highlighting is the relatively low virtual supplier integration which emphasizes the current limitations of End to End value chain assessment and optimization. Only few companies indicate that they are currently in a position to exchange business critical information with key suppliers to synchronize internal and external business processes. It remains to be...
Advanced information technologies, increasing volatility in the company environment, customization of customer requirements as well as increasing product complexity cause new challenges for manufacturing companies.

This chapter documents the expected implications of these trends on the next stage of Lean.

According to Figure 17 the overwhelming majority of participants expect that Lean and Digitalization will be mutually beneficial. 56% of all companies consider Digitalization as Enabler for Lean rather than a substitute for Lean. At the same time, Lean is seen as foundation for a successful implementation of digital technologies (38% of all companies). Only a small minority of 4% predicts a coexistence without mutual impact and none of the participant in the study expects Lean to be replaced by Digitalization. In summary, Lean responsible expect a positive mutual impact between Lean and Digitalization, with both having their 'raison d’être'.

A senior Lean expert summarized the general understanding of almost all participants by indicating, that stable and standardized processes need to be established in the analog world first, before being digitalized.

Thomas Walke
Head of Lean Management
Swisscom AG

“If we do not apply Lean principles, we will digitalize waste.”

<table>
<thead>
<tr>
<th>Figure 17</th>
<th>Expected impact of digitalization on Lean Management</th>
<th>n = 73</th>
</tr>
</thead>
<tbody>
<tr>
<td>All companies</td>
<td>56%</td>
<td>38%</td>
</tr>
<tr>
<td>Leading Companies</td>
<td>65%</td>
<td>30%</td>
</tr>
<tr>
<td>Follower</td>
<td>53%</td>
<td>42%</td>
</tr>
<tr>
<td>Experience &lt;5 years</td>
<td>52%</td>
<td>42%</td>
</tr>
</tbody>
</table>

- Digitalization will support LEAN
- LEAN is the foundation for implementing Digitalization successfully
- Digitalization and LEAN coexist with no major impact on each other
- Digitalization will replace LEAN
- Don’t know
Lean is and will increasingly be a key enabler for future competitive advantages.

The question to what degree Lean will be relevant for staying competitive in the next five years, led to a very consistent answer. According to Figure 18, 90% of the participants are convinced that Lean will be increasingly relevant in the future, compared to only 1% arguing the opposite.

Within the peer group of the Leading Companies, the share of participants, expecting an increasing relevance of Lean for competitiveness is even higher (95%).

The following quote of Jost Fastenrath puts the understanding of Lean as key enabler for future competitive advantages in a nutshell.

“Without radically optimizing the processes, focusing on costumer value avoiding waste we will run sooner or later out of business. The only way to optimize our processes in a sustainable way, is to follow the Lean philosophy.”

**Figure 18**
How critical do you think will Lean be for staying competitive in the next five years?

n = 72
Cost pressure is still the main challenge for Lean manufactures. For leading companies non-financial requirements are more relevant than for companies within the Follower group.

Lean strives for reduction of waste along the whole value chain. Hardly surprising, therefore, is the fact, that Cost pressure for most companies is still a major challenge (Figure 19). Product complexity is the second main challenges, however, in a similar range as Volatility. A spread between the four groups is only visible in regard to Customization.

Whereas this aspect is in general less perceived as a major challenge, Leading Companies attach a significant higher importance to Customization of customer requirements compared to Follower or companies with less Lean experience.

**Figure 19**
With regards to Lean performance, what will be the major challenges in the next three years? n = 75

<table>
<thead>
<tr>
<th></th>
<th>All companies</th>
<th>Leading Companies</th>
<th>Follower</th>
<th>Experience &lt;5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost pressure</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Product complexity</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Volatility</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Customization of customer requirements</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Culture and employee development & qualification are the key enablers for the “The next stage of Lean”

Enablers are a set of necessary skills and capabilities to achieve a specific goal. According to Figure 20, culture is still considered as the most critical Enabler to achieve the next stage of Lean. Culture comprises aspects such as motivation and employee involvement in Continuous Improvement activities.

Closely linked to culture is employee development & qualification. Employees need to be trained to use new technologies effectively as well as to sustain the Lean philosophy. The clear priority shown for this two Enabler demonstrates the outstanding importance of employees for implementing Lean successfully.

The highest Enabler that is not human related is process development, reflecting the high relevance of processes for reducing waste along the value chain. The next category is supplier relationship & collaboration, followed by planning for uncertainty. Technology usage is not among the top Enablers. This indicates the understanding of a majority of Lean practitioners, that technology alone is not a driver of higher performance. Only in combination with a motivated and qualified workforce new technology can be applied effectively and thereby contribute to better operational performance. Comparing, the different groups, Figure 20 indicates that Leading Companies rate technology usage higher than less mature companies.

Figure 20
How important are the following Enablers for “The next stage of Lean”? n = 72

1 = Not important, 2 = Slightly important, 3 = Highly important
Big data analytics and automatization & robotization have great potential to improve Lean ...

Although participants do not consider Technology usage as critical enabler to achieve the next stage of Lean, a majority of participants see significant potential in using digital technologies to improve Lean performance (Figure 21).

Especially Big Data, including the collection and analysis of manufacturing data is seen as promising trend to further increase the productivity of Lean Production systems. Companies consider for example root-cause analysis of quality issues based on manufacturing data as auspicious approach for sustainable quality improvements.

Automatization & robotization is also perceived as technology, which will (continue to) have a positive impact on Lean. Especially lead time reduction and productivity gains are expected to achieve by a higher level of automation.

Besides using robotics for production and assembly technically advanced companies have also implemented so-called autonomous guided vehicles (agv). According to one of the Leading Companies, the automated intralogistics resulted in considerable fewer accidents and a strong reduction of damaged goods.

Internet of things is considered as promising technology, however, we have seen few examples of decentralized flows of information between different devices. The technology is likely to have a larger impact on the manufacturing sector not before 2020+.

Compared to the first three technologies, additive manufacturing, which includes 3D printing, is expected to have rather minor potential for Lean companies.

---

**Figure 21**

What potential do the following trends of digitalization provide to improve Lean? n = 73

1 = No potential, 2 = Minor potential, 3 = High potential

---
... and these technologies are expected to support the realization of the five Lean principles.

In their well-known publication Lean Thinking, the authors Womack and Jones (2003) argue that an organization can become Lean by following five core Lean principles.

The first principle is to Define Customer Value. Therefore, companies need to get a deep understanding of the desires and the unsolved problems of their customers. Only then companies are able to develop and produce products and features their customer aspire and are willing to pay for.

The second Lean principle is Identification of the Value Stream. This principle includes the identification of value adding and non-value adding activities along the value chain. By continuously reducing the share of non-value adding activities, processes get leaner and more efficient over time.

The third principle is Flow. In Flow production process steps are arranged in sequential order so that the product moves from one step to the next without being stocked in between. Flow production also implies a holistic view on the end-to-end process as opposed to silo thinking, whereby each process step is optimized individually. Flow production dramatically reduces throughput times and work in progress (WIP) inventories.

The fourth principle is Pull. Following this principle implies, that a process step only produces parts when triggered by the need for the parts from the downstream process step. Therefore, Pull production explicitly limits the amount of work in process in the production system. This results in faster lead times and reduces inventory related costs.

The final principle of Lean Production is to Seek Perfection. Perfection means the entire elimination of muda. Although this objective is impossible to achieve, striving for perfection, or in other words, Continuous Improvement is a cornerstone of every Lean operation. Continuous Improvement requires to iteratively work on the first four Lean principles to increase customer value creation while reducing waste.

Figure 22 provides an overview on participants expectations on the potential of digital technologies to support the five Lean principles described above. In general, one can say that the participants of the study see the highest potential to positively impact Lean principles in Big Data. In total, it was selected 172 times (multiple answers possible) as promising technology to support the principles. Especially in the area of defining Customer Value and the identification of the Value Stream, participants expect large benefits in analyzing (manufacturing and customer) data from different sources.
What potential do the following trends of digitalization provide to support the five Lean principles? n = 73
1 = No potential, 2 = Minor potential, 3 = High potential

Internet of Things (IoT) technology (mentioned 158 times) and Automatization & Robotics (147) are on a similar level. Both technologies are considered as promising to enable Flow and Pull production.

Participants expect, that a higher level of robotic and IT integration will support the reduction of lead times and will foster a smoother process with low levels of WIP inventory needed.

The fourth trending technology, Additive Manufacturing, has received the least attention of the study participants. For all five Lean principles, the technology is underrepresented as perspective support. Nevertheless, for Continuous Improvement and defining Customer Value, participants see some potential in Additive Manufacturing.
Lack of management capabilities of digital technologies and shortage of man power are the currently most critical barriers for applying digital technologies to support Lean.

As seen above, participating companies recognize the potential of integrating digital technology to improve their Lean operation. However, currently most companies hesitate to arrange large investments into digital technologies. The main reasons for this reluctance are a number of barriers that needed to be overcome to successfully implement digital technologies and utilize them to support Lean Production. Figure 23 provides an overview on eleven identified barriers.

**Figure 23**
What are barriers to improve Lean by utilizing digital technologies? n = 70
1 = No barrier, 2 = Minor barrier, 3 = Major barrier
Figure 23 clearly indicates that the participants consider a lack of experience and subsequently a lack of management capabilities of digital technologies as the main barrier. Quite in contrary, Lean Management capabilities are perceived as less critical. The message, however, is not that this capability is not relevant, but instead that the participants evaluate their existing Lean Management capabilities as mature enough to integrate new technologies into the Lean Production system.

Further important barriers are shortage of man power as well as employee qualification. Budget restrictions is only ranked on position four of most relevant barriers. This result demonstrates, that introducing digital technology is not primarily about buying the newest technology available on the market but having the right personal with the right qualification available.

This is especially true for the group of Leading Companies, which consider shortage of man power as the most critical barrier, whereas budget restrictions and infrastructure restrictions are perceived as less challenging.

State of the art of technology utilization

A look on the current state of technology utilization provides a mixed pictures (Figure 24). IT systems such as the Enterprise Resource Planning (ERP) and the Customer Relationship Management (CRM) system are widely rolled out in most companies or at least implemented in some parts.

In addition, participating companies heavily make use of inline measurement and inspection systems. The midfield of the technology usage ranking list is also dominated by IT systems such as PLM, MES and SRM systems. In average, companies are slightly beyond the testing phase and started to implement these systems.

Rather new technologies such as 3D-Printing, Autonomous transportation, RFID chips, smart robots and Augmented reality are clearly lacking behind. These technologies are in average between no utilization and the testing phase.

Besides ranking the listed technologies, Figure 24 illustrates the pioneering role of Leading Companies in terms of technology utilization. They are advanced in all technology categories and invest more in particular into testing new technology such as Autonomous transportation, RFID technology and Smart robots.
IT systems in general and especially ERP systems are already in use, while new digital technologies are still in the testing phase.

**Figure 24**
Which of the following digital technologies are you currently using? n = 70
1 = No utilization, 2 = Testing phase, 3 = Implementation, 4 = Widely rolled out
The utilization of digital technologies will support Lean methods – especially Root Cause Analysis, Kanban and Visual Control ...

In order to increase value creation and reduce waste along the value chain, Lean companies apply several well-known Lean methods such as Kanban, 5S and Poka Yoke. This question investigates, whether and to which extent, companies expect digital technologies to have a supporting impact on these Lean methods.

Figure 25 reveals that the participants expect a positive impact of digital technologies especially on root cause analysis, Kanban and visual control. For example, using data from manufacturing is expected to support the root cause analysis of product and process quality issues. Since digital technologies bear the potential to improve interactions along the entire value chain, they can also help companies to enhance Kanban systems to improve internal and external material supply. Kanban systems have become the standard approach to implement JIT production but often lack flexibility to meet the needs of dynamic manufacturing environments. Finally, visual control is estimated to benefit from digital technologies, e.g. by using monitors to present the most relevant and up-to-date information. Figure 25 also indicates that Leading Companies are in general more optimistic in their estimation of the supporting impact of digital technologies on Lean methods.

**Figure 25**

What is the impact of digital technologies on the following Lean methods? n = 70

1 = No impact, 2 = Minor impact, 3 = Major impact
... and will facilitate the optimization of process parameters and end-to-end planning across the value chain.

Figure 26 evaluates the impact of digital technologies on Lean from a more general perspective. Participants expect that digital technologies have a strong impact on almost all listed aspects of Lean. Especially the optimization of process parameter is regarded as promising application of new technology. One can think of preventive maintenance and AI applications to identify the best parameter settings for high quality and high overall equipment effectiveness (OEE). Furthermore, a holistic end-to-end approach for planning as well as simulation of material and work flows will be facilitated by digital technologies.

In contrast to process related improvement opportunities, the participants foresee few potential to create new revenue streams. It is likely, however, that this assessment is biased due to the fact, that most of the contacts filling out the questionnaire have roles within the manufacturing realm.

Compared to the overall sample, Leading Companies see more potential in applying digital technologies for end-to-end planning and especially for improving the execution of Lean principles on the shop-floor.

**Figure 26**

Where do you see improvement potential for Lean due to digitalization? n = 71

1 = No impact, 2 = Minor impact, 3 = Major impact

![Chart](chart.png)
Leading companies have a higher share of production technology equipped with real-time monitoring functionality.

Almost half of the participants (45%) state that they have only a small share (0 – 20%) of their production technology equipped with real-time monitoring functionalities. Only one out of eight companies has a very high share with more than 80% of the equipment using real-time monitoring.

As can be seen in Figure 27, the group of Leading Companies has in average a considerably higher share of monitored equipment. This peer group has almost twice as often indicated to have real-time monitoring in place for more than 80% of the equipment.

Also, only one out of three Leading Companies has indicated that none or less than 20% has real-time monitoring functionalities.

Production equipment with sensors is a vital part of the technological foundation of many digital technologies. As seen before, a lot of companies expect quality improvements from Big Data analytics. However, Figure 27 illustrates, that to this day, only a comparably small share of equipment is ready to provide manufacturing data in real time. To be able to react quickly to unexpected events, requires access to (near) real-time data. This in turn demands a high share of equipment with sensors that efficiently feed back data into the company’s IT systems.

![Figure 27](image_url)

What proportion of your production equipment makes use of real-time monitoring? n = 64

<table>
<thead>
<tr>
<th>Category</th>
<th>&lt; 20%</th>
<th>20-40%</th>
<th>40-60%</th>
<th>60-80%</th>
<th>&gt; 80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>All companies</td>
<td>45%</td>
<td>17%</td>
<td>16%</td>
<td>9%</td>
<td>13%</td>
</tr>
<tr>
<td>Leading Companies</td>
<td>37%</td>
<td>11%</td>
<td>11%</td>
<td>16%</td>
<td>26%</td>
</tr>
<tr>
<td>Follower</td>
<td>49%</td>
<td>20%</td>
<td>18%</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>Experience &lt;5 years</td>
<td>48%</td>
<td>16%</td>
<td>16%</td>
<td>6%</td>
<td>13%</td>
</tr>
</tbody>
</table>
In average, the overall sample generally applies descriptive and diagnostic analytics. Leading Companies are more advanced and also make use of predictive analytics.

Literature distinguishes four levels of data analytics (Figure 28). The first level is called *descriptive* analytics. Analysis of this type aim to answer the question “what happened” and is purely descriptive.

The second level is *diagnostic* analytics, which addresses the question “why did it happen”. Analysis of this type provide insights on the root-causes of a given phenomenon, e.g. quality issues in the packaging process.

The third level is *predictive* analytics. Predictive analytics addresses the question “what will happen” and seeks to predict future outcomes. By using statistical and data mining techniques, drivers of observed phenomena are identified.

The fourth level is *prescriptive* analytics. Prescriptive analytics addresses the question “what should be done” and combines describing, understanding and predicting with suggesting approaches to achieve a desired future state.

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**Figure 28: Data Analytics Maturity Model (Source: Gartner Inc.)**
For capacity planning, root-cause identification and waste reduction, companies today mostly apply diagnostic analytics (Figure 29). The ability to react quickly on changing demands and orders is currently less supported by data analytics. Companies seem to struggle to derive the right diagnostics from data to improve flexibility.

Consequently, a comparably high share of companies only applies descriptive analytics to increase quick response capabilities. Again, Leading Companies take a pioneering role in terms of data utilization. The curve of the Leading Companies is similar to the curve of the overall sample, but on a significant higher level. These companies utilize predictive analytics much more frequently.

*Figure 29*
What type of data analysis do you utilize to ... [internal value stream] n = 62
Nature of analysis: 1 = No analysis, 2 = Descriptive, 3 = Diagnostic, 4 = Predictive, 5: Prescriptive
Data Utilization – Customer Value

In an increasingly customer-centric world, the ability to capture and use customer insights to shape products, solutions, and the buying experience as a whole is critically important.

McKinsey (2017)

Prerequisite for delivering customer value is understanding the customers’ needs. CRM data, online surveys and social media are valuable sources to analyze and improve the understanding of customers’ demands.

From Figure 30, it can be seen that Customer complaints is the most relevant source for companies to get a better understanding of their customers’ needs. All companies finishing this question indicated that they use this data to improve their products and services in terms of providing more customer value. Also explored by a vast majority (62 of 65) of the companies are Sales data.

In addition, around 75% get and analyze feedback from their customers in form of customer usage data. Some of the more advanced companies have established a direct data link between products installed at the customer to collect more and more up-to-date customer data. By analyzing the customer usage data, companies can identify features which are especially valued by the customer. These insights are a very valuable to define priorities for the further development of the product. Although quite present in current discussions, for our sample Social media data is far less relevant to define customer value. It is only used by around a third of the companies.

Figure 30
What data do you analyze to better define customer value? n = 65

Frequency of selection per peer group (multiple selections possible).
The availability of data in the right quality is currently the greatest challenge part of getting insights based on customer data analysis.

Figure 31 clearly illustrates that for most companies the major challenge to identify customer value based on data, is to collect the data in the right quality. The essential role of data quality is also confirmed by the fact that 73% of all participants have identified this factor as challenge.

The second key challenge is to handle a variety of data sources and data formats. It is named nine times as largest challenges and has the second most nominations as general challenge. Deriving the right conclusions from the data is for six of the companies the key challenge.

The same applies for having the results of analysis in a timely manner, so that actions can be derived quickly.

Participants show not too much concern about the question how to transfer the insights gained from analysis into the development process of new products or services. This result might be influenced by the fact, that most participants have manufacturing related roles and therefore have their focus rather on operations than on product or service development.

Figure 31
Which is currently the most challenging part of getting insights based on customer data analysis?

n = 70
Frequency of selection per peer group (Rang 1 = largest challenge).

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Rang 1</th>
<th>Rang 2</th>
<th>Rang 3</th>
<th>Rang 4</th>
<th>Rang 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability of data in right quality</td>
<td>31</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Handling of variety of data sources and data formats</td>
<td>9</td>
<td>13</td>
<td>11</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Interpretation of data analysis</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Timely availability of results of analysis (velocity)</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Transfer of insights into the development of new products or services</td>
<td>2</td>
<td>12</td>
<td>8</td>
<td>9</td>
<td>11</td>
</tr>
</tbody>
</table>
73% of all companies are already investing today or planning to invest in IT-Infrastructure to improve their capabilities to define customer value based on customer data. 31% of all companies are currently hiring data-affine employees.

Figure 32 visualizes the planned investments of the participants in IT systems as well as data analysis know-how. Data is the basis for data analysis, consequently one can currently observe a high investment rate into IT systems, such as IT-infrastructure and CRM software. Only 18% of the participants do not plan to invest into IT infrastructure.

While Figure 32 demonstrates a backlog for IT systems, it also indicates the need of companies to build data analysis capabilities.

Almost one third of all participants are actively hiring new employees that already bring data analysis skills with them. An additional share of 18% plans to do so within the next three years. Furthermore, 27% of the companies have started to build data analysis capabilities by training employees internally. More than a third share the vision of internal capability building but has not started with training yet. Providing consultancy services in the field of data-based customer value definition is likely to be a lucrative market as 46% of the participants make use of or will consult external professionals for support.

Figure 32

In order to improve our capabilities to define customer value, based on customer data, we invest/are planning to invest in the following? n = 72

<table>
<thead>
<tr>
<th>IT Systems</th>
<th>Over all companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT-Infrastructure (servers, sensors etc.)</td>
<td>49%</td>
</tr>
<tr>
<td>CRM (Customer Relationship Management)</td>
<td>45%</td>
</tr>
<tr>
<td>PLM (Product Lifecycle Management)</td>
<td>32%</td>
</tr>
<tr>
<td>Hiring new employees with data analysis skills</td>
<td>31%</td>
</tr>
<tr>
<td>Training to internally build data analysis capabilities</td>
<td>27%</td>
</tr>
<tr>
<td>External consultancy services in the field of data analysis</td>
<td>20%</td>
</tr>
</tbody>
</table>

Data Analysis Know-How

- Investing today
- Plan to invest within 3 years
- No plans to invest
- No answer
What is the next step in Lean regarding Digitalization?

At the end of this section, the authors of this study like to step back and present selected answers of our participants to the question raised above.

For us, the next step in Lean regarding Digitalization means ...

"... support data analysis to faster get a value stream mapping done."

"... gaining direct data-based insights on where the biggest potentials for optimisation and the next improvements are, as opposed to relying on opinions and prioritising them."

"... creating total E2E visibility of customer demands."

"... on time visualization of the status of entire value streams (actual throughput-time, WIP, etc.); workload-balancing based on real demand instead of forecast."

"... having a group-wide architecture and decisions for global software-solutions (e.g. MES). IT-structure and implementation of the right hard- and software structures is the biggest challenge for the companies which is widely underestimated."

The selected citations above are representative for a majority of the participants. Access to data, the right IT infrastructure and the ability to gain actionable knowledge from the data is the key element to use Digitalization to bring Lean to the next stage. However, we also found critical voices that remembered us that Lean is not primarily about technology but rather about a mindset of continuous change.

"You should not eliminate waste to get resources to collect big data which gives you no answers [...] Digitalization is not always helpful, but needs a lot of time and maintenance ..."

"Lean is not a question of digitalization. It is a question of culture and thinking!"

Unquestionably, digital technologies will play a role in the future of Lean Production, but it is not the simple solution to all challenges. Also discussing the role of digitalization in Lean production systems, the future will not be binary, but – as it is often the case – management needs to find the right balance of investments into new technology and efforts to maintaining the right Lean culture, which includes customer value orientation, process and quality focus and the permanent quest for Continuous Improvement.

"Finding the right dose to merge Digitalization and Lean and make this insight basic understanding for management."
Conclusion

Status Quo

In this study we have investigated the current state of Lean Production and have made an attempt to uncover a pathway to the next stage of operational excellence. In this context we have discussed Lean objectives and planned achievements together with current capabilities. Additionally, we analyzed challenges, opportunities and apparent trends in order to sense what Lean will look like in the near future. As a result, we can expect that traditional Lean paradigms will remain relevant in tomorrow’s business environment. Furthermore, in order to exploit the estimated potential of digital technologies companies need to overcome well-known challenges of production management such as employee development and culture. In a nutshell in order to reach the next stage based on new technologies one needs to address rather traditional problems first.

Based on insights from 75 companies from 14 industries and from 15 countries this study takes into account a variety of company specifics. The results of the quantitative survey are backed by 10 detailed case studies conducted to identify four Leading Companies. After having challenged the relevancy of the five Lean principles, we conclude that Lean will remain and may even become increasingly important for competitiveness in the future.

The next stage of Lean

Almost 90% of the survey participants state that Lean will stay and even become increasingly relevant for competitiveness in the future. However, companies need to evolve to increase both effectiveness and efficiency of their Lean Production systems. When it comes to enabling factors for the next stage of Lean, the two enablers Culture and Employee development & qualification, are selected as most critical. While one might draw the conclusion from this that the use of digital technologies is of subordinate importance for the next stage of Lean, it is more like the facts that just having access to digital technologies is not enough. Instead, companies claim that they lack the capabilities (skilled) man power to properly manage digital technologies and for a sufficient integration of digital technologies into Lean systems. Accordingly, despite high initial costs of digital technologies, budget restrictions are only rated to be of subordinate importance.

Summarizing, a majority of survey participants is convinced that digitalization will help achieving the next stage of Lean. However, there were also critical voices implying that Lean is not about technology but about culture and mindset. In conclusion, balancing both concepts – Lean and Digitalization – to exploit their full potential will be the main challenge for the management and finding the right balance will be key to achieve the next stage of Lean.
Publication Bibliography

Appendix

We would like to cordially thank everyone who participated in our benchmarking!

About us

The Institute of Technology Management at the University of St.Gallen was founded in 1988. We maintain close links to industry through intense collaboration with Swiss and European organizations by means of major research and consulting projects.

Our Division Production Management offers industrial organizations both industry and functional expertise, advisory and benchmarking competencies, and academic research. An experienced team of 60 researchers supports you in order to increase your future competitive advantages, from identifying the greatest improvement opportunities to their implementation.

The Institute of Technology Management is one of the leading European benchmarking institutes with more than 100 international studies over the past 15 years. With this experience as well as our systematic and efficient benchmarking approach we can guarantee high quality and scientific validity of results.
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