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LEANNESS LEVEL OF MANUFACTURING COMPANIES – A SURVEY ON LEAN MANUFACTURING IMPLEMENTATION

[Úroveň štíhlosti výrobních podniků - průzkum zavedení štíhlé výroby]

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Abstract: Lean manufacturing is a well-known methodology to optimize company processes towards the increase of company performance. Despite the fact its benefits were confirmed over many years, the rate of successful implementations is questionable. This article focuses on an evaluation of the leanness level given by a level of implementation of lean manufacturing methodology in manufacturing companies. It brings results gained from the survey made in the production companies related to the Czech Republic. The survey focused on an evaluation of the use of basic lean manufacturing tools. Based on acquired data, the leanness level of the companies was calculated. Results showed that an overall average leanness level is 56%. Big differences between large companies and small and medium companies were found. A gap between theoretical promoted tools and their utilization in real companies was found as well. There is a discussion on the possibility of improving the level of leanness.

Keywords: lean manufacturing, lean tools, leanness, performance measurement, production management.

JEL classification: M11

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Introduction

Production companies face a lot of challenges in the markets. Pressure on efficiency is increasing, and crises that came in the past showed, that not only the companies with the highest performance but also with high flexibility can survive and gain benefits over the others. Lean manufacturing is a well-known methodology of optimization of production processes in a company. Its benefits were proven by many researchers as well as achieved results in many real companies. However, still, there are a lot of companies that do not use the benefits of lean manufacturing methodology or have problems with proper implementation.

In the survey, the target was to map the current situation in a production companies in the Czech Republic and some companies abroad which ensure a production of products for companies located in the Czech Republic. Company representatives were asked about the level of implementation of the 10 most important lean manufacturing tools. The leanness level was calculated based on the responses. 50 completed questionnaires were obtained, which allowed to create an overview about the leanness status of those companies and to understand which lean manufacturing tools are in the companies used more often than others.

The first part of this article consists of a literature review about lean manufacturing and related topics. Then, an explanation of the survey is presented and followed by a description of gained results. The discussion about calculated leanness level follows, and a conclusion with a summary of results and limitations of the survey is placed at the end of this article.

1 Literature review and theoretical background

In the beginning, an explanation of lean manufacturing, lean tools and leanness is presented. Shortly, challenges linked to the implementation of lean manufacturing are touched.

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Lean manufacturing

The word "Lean" was firstly used to name the methodology used by Toyota in the second half of the 20th century by Krafcik in 1988. Taiichi Ohno is taken as a father of a set of tools and methods, which together form the Toyota Production System, which is later called lean manufacturing. "Lean" represents the fact that this organization of production needs less of all resources compared to other systems (Samuel et al. 2015).

There are many definitions of lean manufacturing (Qing Hu et al. 2015). Womack defines lean production as a strategy or a philosophy that promotes the use of practices, such as kanban, total quality management and just-in-time (JIT), to minimize waste and enhance firm performance (Womack et al. 1990). Kanban and JIT are combining to create a pull system in lean manufacturing. Compared to push systems (like common MRP-planning as a part of almost all company information systems), pull systems are driven by customer needs and controls the level of stocks and on-time deliveries to customers (Junior and Filho 2010). Lean production is 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). Lean production can be described as the systematic elimination of waste (Liker 2004). Lean production is a manufacturing strategy, which strives to minimize waste and thereby increase efficiency (Hofer et al. 2012). Lean manufacturing is a set of synchronized methods and principles to control production companies. It describes a way of organizing production independent of technologies for achieving of shortest lead times with minimal costs and best quality (Ohno 1988).

The main positive effects of lean manufacturing are on deliveries to customers (shorter delivery times, better on-time delivery, etc.), on quality (lower material consumption and defects rate, fewer customer complaints, etc.), and costs (better machine and space utilization, higher productivity, etc.). Many empirical studies have proven overall positive effects on company performance (Santos Bento and Tontini 2018, Wickramasinghe and Wickramasinghe 2017). An important fact about lean manufacturing is that thanks to the use of the philosophy of continuous improvement, it is possible to gain long-term profit without the need for huge investments into the organizational infrastructure of the company (Santos Bento and Tontini 2018).

Lean tools

The basic principle of lean manufacturing is the elimination of wastes. Waste is everything that increases costs and does not add value for the customer (Tuček and Dlabač 2012). In Toyota 7 types of waste were identified (Liker 2004):

1. Unnecessary transport or conveyance
2. Excess inventory
3. Unnecessary motion
4. Waiting (time on hand)
5. Overproduction
6. Defects
7. Overprocessing or incorrect processing

The target of lean tools is to eliminate these wastes or reduce them at least. Some tools focus only on one type of waste, others are more complex and focus on more types of waste. The tools are mainly related to the organization and visualization of operations in production. The benefit is seen that in its purest form they are free of information technology (Buer et al. 2018).

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Bhamu and Sangwan, based on their review of literature, created a list of the most common tools in order of frequency of appearance in scientific publications (Bhamu and Sangwan 2014):

1. Value Stream Mapping (VSM)
2. Kanban / Pull system
3. Just In Time (JIT)
4. Total Productive Maintenance (TPM)
5. 5S
6. Cell production
7. Continuous improvement
8. Total quality management (TQM)
9. Kaizen
10. Single Minute Exchange of Die (SMED)
11. Multifunctional teams / Involved employees
12. Heijunka – levelled production
13. Visual control
14. Relations with suppliers
15. Poka Yoke – mistake-proof operations
16. Standardization
17. Simulation
18. Automation

Based on the literature research and an experience of author, for the evaluation of the level of leanness were used following 10 tools in the survey – 5S, SMED, Pull system, Kaizen, Visualization, TPM, TQM, Poka-yoke, VSM and Standardization. These are seen as the most critical and the most common in a process of lean manufacturing implementation.

Tool 5S is used to organize the workplace. It comprises five steps – Sort (clean the workplace from unnecessary material, tools, and other items), Set in order (establish the organization of all items needed on the workplace), Shine (regular cleaning and keeping of set order on the workplace), Standardize (setting of standards for order and needed processes for keeping it) and Sustain (regular checks of keeping the standards and future improvements).

SMED is used for an improvement/shortening of a time needed to change-over from the production of one type of product to another. This is needed for better utilization of machines and to be able to decrease production batches. This improvement can bring an increase in the flexibility of production and speed up reaction on customer wishes.

Pull system is one of the basic principles of lean manufacturing. It is a complex tool that focuses on the planning and scheduling of production. It is driven by customer needs. The most famous technique of this tool is a kanban. Kanban is a system of cards, which are limiting the amount of Work-In-Process in production and allow to start the operation only when there is a request from the following operation (this request is represented by a kanban card).

Kaizen is another important principle and tool of lean manufacturing. The main idea behind it is continuous improvement as a philosophy of small incremental changes, which can keep the adaptability of a company and bring long-term profitability.

Visualization is a tool helping with the organization of a shopfloor and the motivation of the employees. There are many techniques behind this tool, which bring more transparency and

information to operators and other staff supporting production and thus improving results such as productivity or quality and helps with better decision making.

Total productive maintenance focuses on the status of machines. It promotes the use of preventive and predictive maintenance. The target is to minimize unplanned breakdowns of machines.

Total quality management emphasizes quality as a most important value of a production system. This tool aims to incorporate all employees and processes into "a creation" of excellent quality for customers.

Poka-yoke, in other word mistake-proof operations, is a tool which focuses on prevention of defects generated mainly by a human mistake. It brings technical solutions, which are in an ideal situation disabling operators to make a bad piece.

Value Stream Mapping is a tool to create an overview of a current organization of operations in production. It focuses on value-adding activities and helps to find potentials for improvement of a performance by a reduction of non-value adding activities. Related to this tool is the next tool, Value Stream Design which target is to design the future ideal organization of the production process.

The target of standardization is to set the standards of production and to document all operations to ensure they will be performed every time the same way. It helps to keep the same quality and to decrease costs by execution of operations the most efficient way.

Leanness

Comm and Mathaisel describe leanness as a relative metric defining if the company is lean or not (Comm and Mathaisel 2000). Leanness describes the level of an adoption of a lean philosophy (Naylor et al. 1999, Wong et al. 2014). Leanness is an attribute of a production system describing the efficiency of conversion of inputs to outputs. Benefits of lean manufacturing are not only about waste reduction, but it is about using less of all resources and generating benefits like shorter lead times, lower costs of storing, less scrap (Sun 2011).

An important attribute of leanness is its measurability. Mostly for a leanness measurement, a comparison with some ideal or worse case is used (Anvari et al. 2013). Some authors use this attribute of measurability in a definition of leanness. For example, Wan and Chen define leanness as a performance level of a value chain compared to an ideal state (Wan and Chen 2008). Problematics of a leanness measurement is still open, and an ideal indicator was not developed yet (Tayaksi et al. 2020). There is no common agreement if it is a qualitative or quantitative metrics (Wong et al. 2014).

Current techniques to measure leanness can be divided into two groups based on the way of obtaining the data needed for a calculation of a leanness indicator. The first group represents methods using a certain survey (mostly in the form of a questionnaire) to obtain needed information from responsible people. The second group represents quantitative methods using objective data and parameters about the system (Cocca et al. 2019).

Implementation of Lean manufacturing

Lean manufacturing is a complex methodology for the optimization of the production system. For this reason, it is not easy to implement it and the success rate is on a low level (Chay et al.

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2015). Jadhav found that only 30% of changes towards lean were fruitful (Jadhav et al. 2014). Yet there are those companies that were successful and gain visible performance results. Unfortunately, there is no universal framework, which would lead to a lean company. There are many approaches, focusing on different aspects of this methodology. People play crucial role, their experience and motivation (Jadhav et al. 2014). A measurement of leanness during the process of implementation has a positive influence on the results (Bidhendi et al. 2019). It is important to set the right target at the beginning and to track the fulfillment of it (Cocca et al. 2019).

In the past some surveys were conducted about the level of implementation of lean manufacturing in the companies. For example, Nordin et al. (2010) made a survey of the 60 Malaysian companies, the result was that most of the companies started the implementation, but they have not reached full implementation and all benefits of it. Zahraee (2016) measured the level of implementation of individual lean tools in 93 companies in Iran. Three surveys from India by Kumar and Kumar (2015), Chauhan and Singh (2012) and Singh et al. (2010) showed that the average implementation level of individual lean tools is 3,89 (on a scale from 0 to 5), but the average complex leanness level is only 0,6178. From that reason Indian companies have big potentials for an improvement. In Brazil, the average leanness level is even lower with value of 0.546 (Lucato et al. 2014). In the Czech Republic two surveys measured the intensity of a usage of lean tools together with other management and optimization tools. Gálová et al. (2018) found that the lean tools Standardization and 5S together with IT planning tools MRP I and MRP II are the most used tools in manufacturing companies. Rajnoha et al. (2018) was comparing the level of a usage of 7 different tools, where 4 of them were lean tools, among manufacturing companies located in the Czech Republic and the Slovak Republic. In the Czech Republic Kaizen and 5S were the most used with an implementation level of 33% and 32%.

2 Methodology of the survey

The data collection was a part of a complex survey, which was focused on a new way of a measurement of the leanness of production companies. This survey consisted of a combination of interview and an electronic questionnaire. During it deep analysis of a production process of companies was made and detailed parameters about production were collected. At the beginning test phase with approximately 10 companies took place. During it, the whole methodology and the questionnaire was tested. After it, main part of a survey took place. Sometimes, it was supplemented by an e-mail or a phone communication if some explanation or clarification of data was needed.

The questionnaire consisted of three parts. The first part was focused on the identification and categorization of a company. Here, questions about the name of the company, contact identification, industry sector, size of the company and location of the company were placed. Data from this part were used for the categorization of each company. The second part consisted of questions about the level of adoption of 10 lean tools. They were: 5S – Organized workplace, SMED – Quick change-over, Pull system, Kaizen – continuous improvement, Visualization on the shopfloor, TPM – Total productive maintenance, TQM – Total quality management, Poka-yoke – mistake-proof operations, VSM – Value Stream Mapping and Standardized work. For each tool, a 3-level scale was used: “Fully implemented”, “Partially implemented”, “Not implemented”. Generally, “Fully implemented” stands for the situation when the process of an implementation of particular tool was finished. Most of the common indicators linked to this tool are placed and the company generate the benefits of this tool. “Partially implemented” stands for the situation when the process of an implementation of particular tools was started but was not finished. Some indicators linked to this tool are visible, but some are still missing.

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Benefits of the tool do not have to be available or only partially. "Not implemented" stands for the situation when the process of an implementation of the particular tool was not started or is at the very beginning when no indicators take place nor the benefits. As an attachment, a description with common indicators of each level of each tool was provided as a clue to help to fill in the right statement. Data from this part were used as an evaluation of the leanness of a company. Finally, the third part consisted of quantitative questions about the parameters of a production line used for detail analysis of a production process. These questions were about lead time, work in process, output level, batch sizes and a specification of a bottleneck operation.

The target of the survey was to get as wide as possible portfolio of different type of companies. The tool Google forms was used to create the questionnaire. This questionnaire was sent to a responsible person in a company who was identified as the most experienced about lean manufacturing methodology and who had good knowledge about measured production. Mostly, they were production managers, logistics managers, lean specialists, etc. The focus was on production companies mainly in the Czech market, but during the survey data from plants from other countries ensuring production for Czech companies were obtained as well. The survey started in 2016, when the testing of questionnaire took place. The main data collection was between years 2018 and 2020. The data collection and following data processing was quite time-consuming.

3 Survey results

Because of specific questions targeting sensitive information especially in the third part of the questionnaire about parameters of a production process, it was complicated to acquire completed questionnaires back from the companies. Response rate to the anonymously sent questionnaires was close to 0. It was necessary to use networking strategy to generate contacts in the companies and some kind of negotiation tactics was needed to get filled questionnaires. Eventually, 50 completed questionnaires were obtained. Of these 50 companies, 14 were located only in one country, where 13 in the Czech Republic and 1 abroad. The rest of – 36 companies were international companies, where 21 questionnaires were about Czech plants and 15 about plants located abroad. Table 1 shows absolute values and relative frequencies linked to the location of those companies.

Table 1: Number of companies in the survey based on the location

Presence of a company	Absolute value	Relative frequency
Local - only 1 state	**14**	**28%**
- Czech Republic	13	26%
- Other	1	2%
International	**36**	**72%**
- Czech Republic	21	42%
- Other	15	30%
Total	**50**	

Source: Own survey

In the survey, there were only 2 small companies. 17 were medium-sized and 31 were large companies. Table 2 shows the number of companies based on the size of a company with relative frequencies.

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Table 2: Number of companies in the survey based on the size

Company size	Absolute value	Relative frequency
Small (1-49)	2	4%
Medium (50-249)	17	34%
Large (250 and more)	31	62%
Total	**50**	

Source: Own survey

Regarding the industry of companies Automotive and Mechanical engineering were on the top with 12 companies each. Table 3 shows the number of companies based on the type of industry with relative frequencies.

Table 3: Number of companies in the survey based on the type of industry

Industry	Absolute value	Relative frequency
Automotive	12	24%
Mechanical engineering	12	24%
Furniture	10	20%
Construction	9	18%
Electronics	2	4%
Plastics	2	4%
Textile	1	2%
Machinery production	1	2%
Other	1	2%
Total	**50**	

Source: Own survey

Results of the second part of the questionnaire about lean manufacturing tools are in Table 4. The most fully implemented tools were 5S and Standardization both implemented in 21 companies, followed by Visualization and Kaizen both implemented in 19 companies. The least fully implemented tool is Poka-yoke. The most "not implemented" tool was VSM in 19 companies, followed by SMED in 17 companies. On the other hand, the least "not implemented" tool was Visualization.

Table 4: Results from the survey regarding individual lean manufacturing tools

Lean manufacturing tool	Fully implemented	Partially implemented	Not implemented	Implemented	Level of usage
5S	21	23	6	88%	65%
Visualization	19	27	4	92%	65%
Standardization	21	20	9	82%	62%
Kaizen	19	23	8	84%	61%
TQM	18	24	8	84%	60%
Pull system	18	23	9	82%	59%
TPM	14	25	11	78%	53%
Poka-yoke	9	29	12	76%	47%
VSM	13	18	19	62%	44%
SMED	11	22	17	66%	44%

Source: Own survey

In Table 4, the total implementation rate for each lean manufacturing tool is visible. This rate is calculated as the number of companies with “Fully implemented” or “Partially implemented” answers divided by the total number of companies in the survey. Here, the most implemented tool was Visualization with 92%, followed by 5S with 88%. The least implemented was VSM with 62%.

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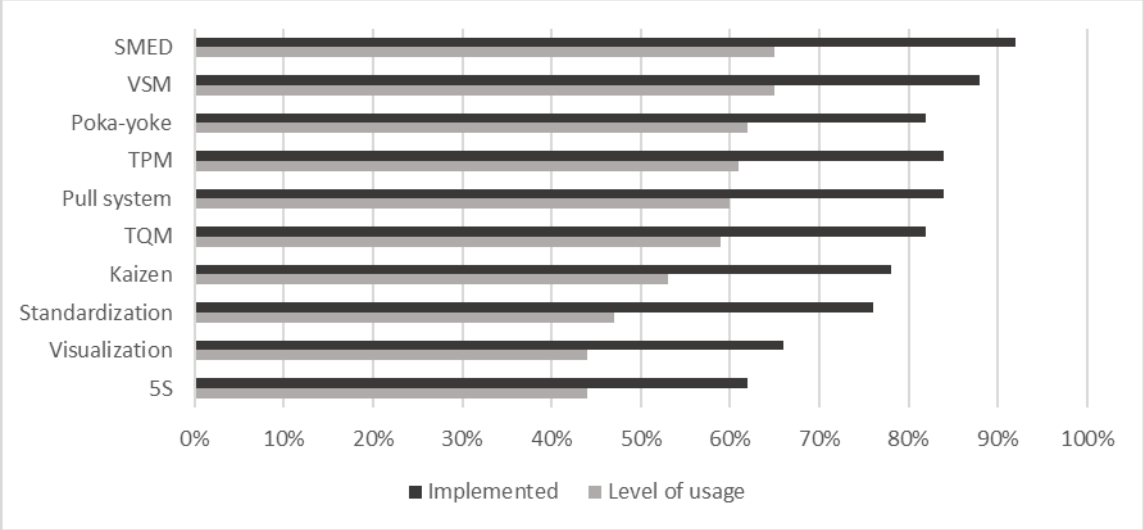
The last column in Table 4 represents the level of usage of each lean manufacturing tool. This level was calculated by scoring the answer "Fully implemented" with 2 points, "Partially implemented" with 1 point and "Not implemented" with 0 points. Then, the sum of earned points was divided by the theoretical maximum points. The highest level of usage had 5S and Visualization tools, both with 65%, followed by Standardization with 62%. The lowest level of usage had VSM and SMED tools, both with 44%.

Picture 1: Implementation and usage level for individual lean manufacturing tools



Source: Own survey

4 Discussion

Based on the level of implementation of each tool, it was possible to calculate the leanness level for each company. The same principle of calculation using 2 points for "Fully implemented" answer, 1 point for "Partially implemented" and 0 points for "Not implemented" was used. 10 tools were evaluated for each company. Calculation of earned points was made for each company and then compared to the maximum of 20 points. 100% is the best possible result, where all tools are fully implemented. 0% is the worst possible result where none of the tools is implemented.

Only 2 companies achieved 100% result and 8 companies had a result of 80% or higher, which can be considered as a lean company. On the other side, the 2 worst companies achieved results of only 15%, which means that they gained only 3 out of maximum 20 points. The average results based on the size of companies and local presence are visible in Table 5. The total average leanness level was 56%. Small and medium companies had a similar level of leanness below 50%. Large companies achieved much better results of 63%. Local companies got almost on a 50% level. International companies were better with over 58%.

Table 5: Average leanness level based on size and location of company

Size/local presence of company	Leanness level
Small (1-49)	42,5%
Medium (50-249)	44,7%
Large (250 and more)	63,1%
Local - only 1 state	49,3%
International	58,6%
Total	**56,0%**

Source: Own survey

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The total leanness level shows there is still a big potential for an improvement of an efficiency of production companies. It shows that only half of the potential benefits of lean tools are being generated and that most of the companies are in a transition mode. That means the initiatives to start with the lean implementation took place, but there is obvious scope for streamlining of an implementation process. This phase will be for many of the companies critical. The way the companies will deal with this challenge now will be crucial if they will be successful and they will start lean journey or if they will fail like many other companies.

Table 6 shows an average leanness level based on the type of industry. Here the industries with only 1 company were put together under one group "other". It is no surprise that the automotive sector gained far the best results with 75% followed by plastics companies with 67%. The worst results belonged to the mechanical engineering industry with only 42%.

Table 6: Average leanness level based on industry

Industry	Leanness level
Automotive	75,4%
Plastics	67,5%
Furniture	57,5%
Other	56,7%
Electronics	47,5%
Construction	45,6%
Mechanical engineering	42,5%
Total	**56,0%**

Source: Own survey

Overall results were not a big surprise. Automotive is a leading industry, where lean initiatives started. In most cases, the plastics industry is in a close relationship to the automotive, so a high level of leanness was expected there as well. A small surprise was the electronics segment, where better results were expected since lean manufacturing is established there. Even though in the survey, there were only 2 companies in this industry. Then, it is not possible to generalize these results for the whole industry. Mechanical engineering is a traditional industry in the Czech Republic with a long history, but with lots of potential for improvement towards lean.

The results of small and medium companies are supporting a statement of Sanders that those companies have much bigger problems with the successful implementation of lean manufacturing compared to large companies (Sanders et al., 2016). It is given that large companies have more resources (capital and personal) to provide needed support for this complicated implementation process. A similar explanation can be used for the difference in results of local and international companies. There is not such a huge gap, but there is still a significant difference.

Interesting results were those about the level of usage of individual lean manufacturing tools. Bhamu and Sangwan (2014) created a list of lean manufacturing tools sorted by the frequency of appearance in scientific articles. In Table 7 there is a comparison of the results of usage of individual tools from research compared to the position in a list created by Bhamu and Sagwan. The results of the 2 most frequently used tools in scientific publications provided by Bhamu and Sangwan shows that in the production companies those tools are not used that much. VSM as number one even gained the worst score of usage in the survey. The question remains what can be the reason for this discrepancy? Could this be the reason why the overall average

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leanness level is only 56%? This shows there is still a lot of potential for improvement and performance increase within production companies.

Table 7: Comparison of results of individual tools with a theoretical importance

Lean manufacturing tool	Position based on Bhamu and Sangwan	Level of usage
5S	4	65%
Visualization	8	65%
Standardization	10	62%
Kaizen	6	61%
TQM	5	60%
Pull system	2	59%
TPM	3	53%
Poka-yoke	9	47%
SMED	7	44%
VSM	1	44%

Source: Own survey

Conclusion

A survey focusing on the level of implementation of 10 lean manufacturing tools was made. In total, 50 completed questionnaires were obtained. The finding was that the overall leanness level was 56%. It indicates companies have some experience with lean manufacturing or they have started with the implementation, but there is a big scope to get on the level of world class lean companies. Comparing the low results of small and medium companies to much better results of large companies show a big gap in a lean manufacturing implementation success rate. We can assume, there are more reasons behind these results, but the complexity and difficulty of the process of implementation of lean manufacturing play indeed a considerable role. Focus on the support of this process in the future by researchers should be placed. For example, an efficient way of leanness measurement can be the tool that could help.

There were some limitations of the survey. The total number of 50 companies is not that high and generalization of the results can be challenging. Extension of the sample of the number of involved companies would be beneficial. The problem is with the willingness of the companies to provide needed data. The way of obtaining needed data about the implementation level of each tool was based on a subjective evaluation of the responsible person in a company. Even the evaluation scale was provided to support the objectiveness of the results, there was still a big portion of subjectivity. The author's main goal is to create an objective method for evaluating leanness levels based on objective production data.

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