

APPLICATION OF LEAN MANUFACTURING TOOLS IN THE AUTOMOTIVE INDUSTRY, A MULTIPLE CASE STUDY

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Purpose: This paper aims to investigate Lean Manufacturing tools application in automotive companies with a special attention to their early stages of introduction. The scope and methodology of Lean tools implementation are identified. Conditions of their successful operation in company's manufacturing systems are attempted to be determined.

Design/methodology/approach: The exploratory multiple case study method is employed in this study. It provides learnings through a real-life investigation in automotive multinational companies' plants. The qualitative data along with insights are gathered by following purposely designed research protocol applied to each investigated case, it consists of open interviews with managers, data and documents analysis along with observations in research objects.

Findings: It was found that investigated Lean tools in three companies operate effectively and bring a lot of benefits. Lean tools need to have a clear vision of how they would contribute to the company's improvement concept before starting their implementation. Appropriate pace of introduction along with carefully considered steps are of special importance, they need to be adjusted individually to a company specificity. Observed tools are typically changed towards better usability and productivity during their use. The responsible team has to be lunched when starting tools implementation, empowerment is necessary, supervisors and line managers should treat Lean tools initiatives with personal involvement. The study discovers that final implementation effect depends on preparation stage and employee engagement.

Research limitations/implications: The study possesses all the limitations typical for the qualitative research method. The conclusions are based on fragmentary view of the three business objects. Studied companies are located in one EU country, Poland. In other regions/countries, the view of Lean tools might differ.

Originality/value: The study provides an in-depth insight in Lean tools application and operation in automotive companies, the automotive industry is leading in Lean implementation. The observations, generalizations and concussions are unique in the literature, the study offers a research input to further studies, it also contributes to management practice.

Keywords: Lean tools, Lean implementation, automotive industry.

Category of the paper: research paper, case study.

1. Introduction

Lean tools implementation is a complex process that requires organizations to determine how to articulate and define Lean journey. Even highly knowledgeable and well-organized companies regularly struggle with it. Preparation stage entails not only setting the goals and choosing process to simplify. Crucial point is to define steps of the implementation and adjust the most suitable tool to the business need.

Lean Manufacturing is a philosophy and a mind-set that helps organizations to identify and eliminate waste and thereby increase the value of business processes. It includes various techniques, enablers and metrics, which find their application in current manufacturing sectors. (Ojha et al., 2014). The main idea behind continuous improvement is a systematic strategy to determine and remove waste activities through looking for opportunities to optimize processes (Taj, Morosan, 2011; Inan et al., 2021).

Various authors have documented quantitative benefits of Lean tools implementation such as increasing overall equipment effectiveness, production cost and defects reduction, improvement in production lead time and cycle time (Belekoukias et al., 2014; Belhadi et al., 2018, Elrhanimi et al., 2016) Researchers indicate also qualitative benefits such as effective communication, job satisfaction, team decision making, work standardization and employee morale (Aij, Teunissen, 2017; Fulleron et al., 2014).

The literature consensus is that the Lean philosophy requires a long-term view, respect for employees, level of patience, focus on processes and the ability to understand where waste happens in the company to use effective Lean tools. Various types of methods and techniques for improving processes have been proposed in the literature. Manuals and consulting industries can help managers and production workers understand how to implement these techniques successfully (Urban, Tochwin, 2022).

This research objectives to investigate of scope and methodology in practical Lean tools implementation in automotive companies. In multiple case studies analysis, researches verify how managers were preparing tools introductions, who are the main stakeholders involved and what are the conditions for successful implementation.

2. Literature review

Importance of process improvement is constantly growing. Any organization that striving to be competitive in the market must keep up with the rapidly changing environment and take full advantage of both continuous improvement tools and technological breakthroughs.

In literature many authors focus on Lean tools implementation in automotive industry. Researches confirm that that appropriate understanding business need and bottleneck inside the organization, effectively support process of choosing proper Lean tool and have positive impact on business results (Ojha, Venkatesh, 2022; Elrhani, Abbadi, 2021; Singh, Singh, 2020; Apafaian et al., 2019). The applicability of Lean initiatives has been proven also in other sectors in the literature by hundreds of successful implementations: pharmaceuticals (Sieckmann et al., 2018), metallurgy (Indrawati et al., 2019), shipbuilding (Sharma, Gandhi, 2017), hospital (Régis et al., 2019), banking (Gong, Janssen, 2015), furniture (Guner Goren, 2017) and also at universities (Balzer et al., 2016).

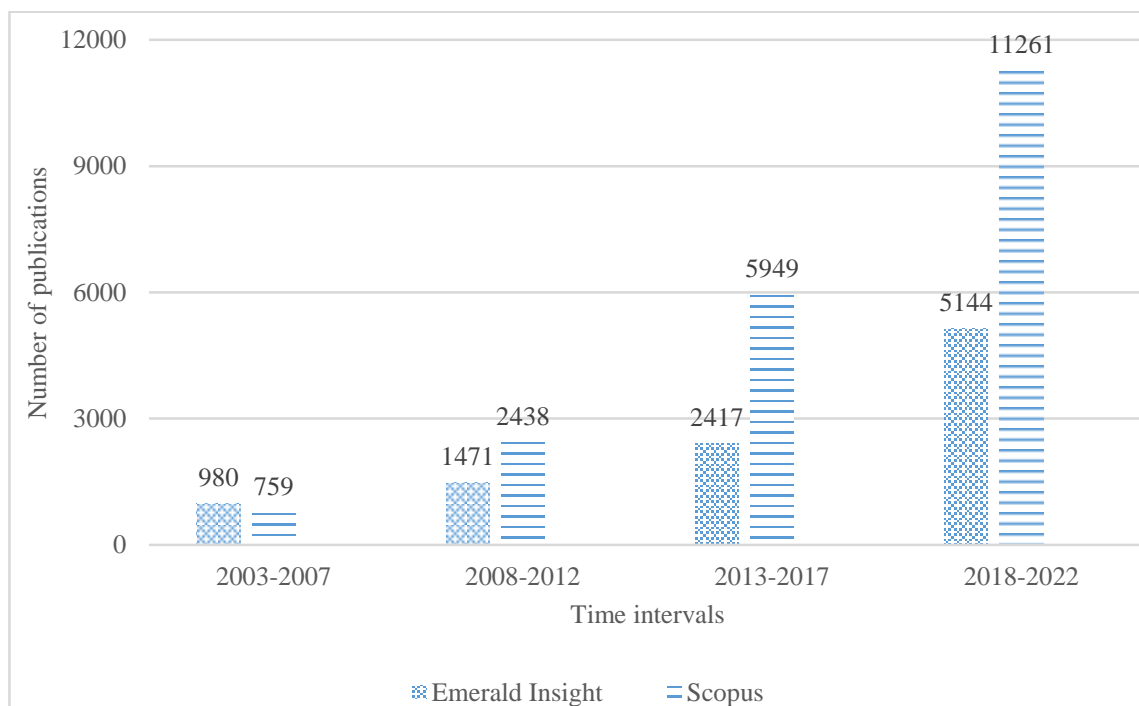


Figure 1. Number of publications in database Emerald Insight and Scopus related to the terms: Lean implementation, process improvement.

Source: own elaboration based on Emerald Insight and Scopus databases (7.04.2022).

Figure 1 introduces trend of rapid grow in popularity of Lean implementation and process improvement topics in literature. Data to prepare this figure was downloaded from 2 online databases: “Emerald Insight” and “Scopus”. The scope of research in both of them was the same by using words: “Lean” and “Implementation” and “Process” and “Improvement”. Year by year, number of publications dedicated to Lean methodology is still increasing, e.g. in Emerald Insight database between 2008 and 2012 1471 researches were published, between 2013 and 2017 it was 2417 publications and in years 2018-2022 5144 researches were published. In case of Scopus database level of increase was even higher: between 2008-2012 2439 researches were published, between 2013-2017 5949 publications and in years 2018-2022 11261 researches were published. About 80% of publications represents scientific articles, about 12% conference papers, about 5% book chapters and 3% other publications.

Another interesting aspect is rapidly increased number of case study publication focusing on practical Lean implementation. In Scopus database between 2000-2010 50 articles were published, between 2011-2020 number increased up to 474 articles and in years 2021-2022 123 articles were published based on case study methodology. In Emerald Insight database rapid increase is also visible. Between 2000-2010 72 articles were published, then between 2011-2020 number of case study articles increased to 180 and in years 2021-2022 123 articles were published based on case study methodology. Data confirmed that scope of this study is very important topic and research can provide for science new interesting results.

Majority available researches (Apafaian et al., 2019; Estorilio, Posso, 2010; Sahoo, 2020; Singh, Singh, 2020) focus on one tool implementation in company. In this publications main objective is to introduce how one particular tool supports business result in researched object. This is a crucial knowledge. Due to analysis of different case studies based on one tool, it is now possible to extract the most important factors during the implementation process.

In literature there are available publications focusing on different tools used in one company from automotive industry (Kim, 2015; Ojha, Venkatesh, 2022; Elrhanimi, Abbadi, 2021). It presents approach to implementation process in particular researched object. All authors define, that lean implementation without deeply understanding onsite is useless.

The contemporary researchers such as: Gupta et al. (2012), Jadhav et al. (2015), Swarnakar and Vinodh (2016), and Dresh (2018), have assessed various dimension of lean practices in auto-component manufacturing plants. Large automotive companies should not only introduce the potential advantages of lean within their own organization but also extend the approach to their components suppliers (Saho, 2020). Crucial aspect is understanding of the relationship between lean initiatives and operational performance in the context of automotive industry (Swarnakar, Vinodh, 2016; Singh, Singh, 2013).

In available literature, sequence of Lean tools implemented in automotive companies has not been researched. This paper provides specific knowledge of what should be determined and consulted in preparation stage. Conducting research in accordance with clearly defined criteria, facilitates the opportunity to carry out a comparative analysis and identify the main similarities and differences between the examined objects.

3. Research methodology

In this study, multiple case study methodology has been chosen to examine the practical Lean tools implementation and their daily operation in automotive companies. To conduct this investigation, crucial data was collected and analyzed using the following techniques: open interviews with the Lean Manager to understand in details the scope of implemented Lean tools, interviews with employees at different organizational levels (production, administration,

planning and logistics employees), analysis of the company's internal documents in the field of Lean tools, direct observations.

A sequence of queries had been elaborated to provide the accuracy and quality of the field investigation. Each of the queries open series of clarifying questions asked during interviews. The list of queries is presented below:

- 1) Which tools are practically and effectively implemented in research object?
- 2) How given tool is used and who was involved in the implementation; how the implementation process went through?
- 3) What benefits has the organization achieved after implementing this tool?
- 4) What were the crucial factors of given tool success during implementation and later use?

The scheme of each case examination was standardized with an appropriate open space to explorations of selected important issues. Investigations in companies were conducted in two steps. First, the interviews with representatives of the company's senior management (Lean Manager or related positions). The issues related to Lean maintenance and company development strategy, Lean tools implementation process and benefits, motivation for improvements, managers and other employees involvement and engagement were raised. The second step relied upon production area visits with Lean Manager. This step included observation of the production process, open-ended questions referred to practical issues of implemented Lean tools in a company, overview of the results presented on tables in production area, discussions of daily management practices with reference to used tools, individual interviews with employees devoted to their involvement in Lean tools implementation and everyday use.

Direct observation facilitated the researchers to collect and verify the information provided by respondents. Any unexpected activity being observed was then tested through discussion with individuals or group of employees at the research object to confirm the validity of the observation. Hence through this approach, as well as quantitative and qualitative data were simultaneously collected. Access to information is a crucial element to conduct effective case study research (Panizzolo et al., 2012; Lande et al., 2016). To conduct the evaluation of Lean implementation even better, deep analysis of the internal documentation was conducted.

Case study investigations were conducted in 3 automotive manufacturing plants in Poland. Owing to confidentiality reasons, the identity of the companies has been masked and a fictitious identity given as company A, company B, company C.

4. Lean tools applications – multiple case study

In Table 1 was introduced basic information about research objects. Study was conducted in one medium size company (Company A) and two large companies (Company B and C). Each company is characterized by the use of two or three main technologies and auxiliary technologies in the entire production process. Observed Lean tools mentioned in the table are operating on daily basis in the examined objects.

Table 1.
Research objects description

	Company A	Company B	Company C
Number of employees	100	450	700
Area of the production plant	6000 m ²	10 000 m ²	13 500 m ²
Main technologies	1) Pressing 2) Pressure welding	1) Injection molding 2) Pressing	1) Electromagnetic coil 2) Injection molding 3) Thermoforming
Implemented Lean tools	1) Visual management 2) Regular board meeting 3) VSM 4) Kaizen suggestion system	1) 5S 2) One Piece Flow 3) VSM 4) SMED 5) Line balancing	1) Kaizen suggestion system 2) VSM 3) SMED 4) Internal improvement system

Company A

Research object was founded in 2012 as a small family production company located in Poland. The main areas of activity focus on the production of pressed steel and aluminum parts and the serial production of pressed body parts for customers in the automotive industry. In order to ensure the highest quality at an affordable price, the company uses the latest technologies of cutting, punching, deep drawing and welding. Production is mainly focused to produce for car concerns such as Mercedes, BMW, Audi and Ford. The company's machine park is equipped with presses of various pressure forces - from 400 T to 1000 T, as well as welding cells and welding devices.

The enterprise has been implementing Lean since the beginning of 2021. Tools such as Visual Management, Regular board meeting, Value Stream Mapping and Kaizen were implemented. To prepare for the implementation, an external company specializing in implementing continuous improvement practices in industrial enterprises was hired. Production manager emphasize that the most important period was preparation phase. Employees haven't had even basic knowledge about implementation process. Together with Lean specialist, main bottlenecks in research object was defined. After that, first ideas about precise Lean tools selection to adjust to business needs were discussed. The next step consists in selecting 14 representatives of various departments of the research facility to take part in comprehensive trainings entitled as Lean Belt. The main goal of this activity was to train employees about Lean

tools, important stages during implementation, key stakeholders and possible obstacles. The next element was to organize internal workshops to develop common approaches to implementation, define communication model and prepare plan how to share Lean knowledge with production workers (main stakeholders). Continuous improvement department supported particular departments in preparation, employee trainings and building engagement.

Company has started Lean journey 2 years ago and already is aware of its first benefits. For example, VSM implementation enabled to identify activities that did not provide added value, eliminate it and reduce stock between workstations by 60%.

Company B

The examined facility is an international concern with over 160 years of experience in the industry. The company specializes in the production of components for the interior of passenger cars and trucks. Key products include door trim systems, console, instrument panels and cockpit and aerated systems. Organization as a whole consists of more than 40 production plants in 15 countries with 13 technical, engineering and sales centers. Research were carried out at the production plant in Poland. Main customers of the company are car concerns such as Volvo, Audi, BMW and Mercedes. The machine park is equipped with e.g. in automatic machines for cutting fabrics and textiles, injection molding machines, laminating machines, CNC machines as well as sewing machines.

Lean tools have been implemented since the beginning of the production plant in 2016. Implemented tools are: 5S, One piece flow, VSM, SMED and Line balancing. Quality manager confirms that building continuous improvement culture is crucial point to achieve effective results. All employees should be involve in the changes. To support such activities, management board established three-persons team. Members represent production, quality and engineering departments. At first, they took part in external workshop to gain basic knowledge about Lean tools and also see examples of practical implementation. In next step, together with management board and selected representatives of particular departments, business needs were defined and an initial plan for the implementation of lean tools has been developed. Continuous improvement engineer defines that the most important factor during implementation is complete understanding of elaborated approach by all stakeholders. Lean project should have high priority and be the part of company's strategy.

First implemented tool was 5S. The main aim was to standardize workstations and show employees how small changes can help in the daily performance of individual tasks. It also helps to improve safety and reduce quality defects. In researched object, the most effective implementation was One piece flow project. It allowed to reduce stock in the whole production process from 1745 to 48 pieces. It also had a huge impact on reducing internal and external quality defects.

Company C

The examined production plant is part of an international concern. It is a leading manufacturer of spare parts in the automotive industry on the primary and secondary markets. The company specializes in design and production of sensors, coils and switches (e.g. pressure, fuel and oil levels, ABS systems and temperature). The company's main customers are automotive concerns such as Ford, Chrysler, Hyundai, Toyota and Volkswagen. The main production lines are equipped with plastic injection molding machines, primary and secondary winding machines as well as vacuum pouring lines with a system of integrated furnaces and testers. The company implements over 100 new finished products annually, which are designed from scratch, tested and then mass-produced in the research plant in Poland.

Continuous improvement has been implemented since 2009. Implemented tools consist of: Kaizen suggestion system, VSM, SMED and Internal improvement system. Lean Manager confirms that Lean tools have a positive impact on reducing waste, improving the quality of finished products and customer satisfaction. To coordinate implementation of particular initiatives, 2-persons team were established. Team members have worked in research object since the beginning of functionality and already implemented their own optimization ideas at the work stations. Production Manager emphasizes, that increasing the efficiency of processes requires the full involvement of employees and openness on change. In the beginning, these two employees were delegated to another production facility of the company where practical Lean solutions are already implemented. Experienced Manager conducted workshop and explained basic knowledge about Lean tools, crucial implementation steps and key success factors. In the next step, Lean department with the support of the management board and representatives of particular departments, developed a concept for implementing the first optimizations. The crucial point was to elaborate trainings for employees to make sure that knowledge inside organization is shared and to link Lean project with the business strategy.

In research object, high levels of engagement employees at all position was observed. Lean culture has been continuously developing since 14 years. It is worth adding that in 2022, the savings generated from all Lean initiatives undertaken in this company will amount to about 1 million PLN.

5. Discussion

Lean tools are designed to eliminate invaluable processes. Implementation is a transformational journey and needs to enable organizational development alongside process improvement. In research objects it was confirmed that the most important is the preliminary stage. Company should develop long-term strategy and define priorities. Customizing Lean tools to the organization's business needs its essential element.

In Table 2 sequence of Lean tools implementation in research objects is presented. Despite the fact, that all the researched companies operate in the same industry, the implementation process was different.

In company A, at the beginning of the Lean journey, visual management and regular board meeting were implemented. The main goal of this activities was to achieve work environment where everyone is aware of defined areas in plant, and knows where to find components needed in production process. Additionally, second objective was improving engagement of all employees in discussion about daily problems and ideas of how they can be solved. When positive effects were seen, company decided to implement Kaizen suggestion system to enable employees sharing ideas about potential improvements at work stations. To identify gaps in process research, object also decided to use VSM (Value Stream Mapping). This tool can help to understand what are value-added activities in process and collect realistic data about efficiency and flow.

Company B has started the implementation from 5S tool. The main goal of the implementation was to increase work safety at the workplace and the quality of products. The standardization of workstations also had a positive impact on ergonomics and order. Visualizations of each production lines were created to define how the equipment in a workplace should look like, and also created location for components and all needed units. Second chosen tool was One Piece Flow. Main objective of implementation was bottleneck identification in processes. To verify where are the main loses, company used VSM tool to develop visualization of current stage and future ideal state. After achieving positive results, researched object invested also in implementation of SMED and Line balancing tools. Starting with the most complex lines, they began to analyze all process steps to identify elements for improvement or complete elimination of worthless tasks.

Company C has decided to implement Kaizen suggestion system. First version of this tool was basic with simply form and rewards system. After few years, system wasn't effective and as a result, number of suggestions decreased rapidly. After that, company decided to developed new version of suggestion system with more complex approach and rewards system to motivate employees. To visualize process and identify losses company used VSM. This tool was used two times already. In 2016-2018 first visualizations were created, and more after two years to verify, that implemented solutions are still working effectively. Achieved positive results, encouraged the company to invest in SMED on the most complex lines (the highest number of changeovers). Finally, Lean teams elaborated "internal improvement system" tool. It is used by production team leaders, who are responsible for development of one improvement project per year. Ideas may concern safety, quality or saving the costs. Elaborated solutions are presented to management board and the most effective are implemented and awarded.

Table 2.
Lean tools implementation sequence in research objects

Year	2009	2010	2011-15	2016	2017	2018	2019	2020	2021	2022	2023
Company A									Visual Management		
									Regular board meeting		
										Kaizen suggestion system	
										VSM	
Company B				5S							
								One Piece Flow			
								VSM			
								SMED			
Company C		Kaizen suggestion system						Kaizen suggestion system			
				VSM					VSM		
								SMED			
								Internal improvement system			

In three research objects, sequence of Lean implementation were different. The whole process is multi-staged. At first, company needs to identify what should be improved, develop a concept with the timeline and elaborate the plan on how to involve employees in this change. In company A, the main identified loss was ineffective communication model between teams and it was a main reason to use visual management and regular board meetings. In company B, problem with maintaining orders and discipline at work stations were identified, and it was a reason to implement 5S. In company C, it has come in a natural way. Production employees have started to report their own ideas of how to simplify process on their work stations. Kaizen suggestion system was developed to allow employees sharing ideas in a more standardized way. It is a perfect example of how smart company should react on internal employee's needs.

Authors also observed main conditions for the successful using of Lean tools. In researched objects, continuous improvement implementation came from the company's development program. Crucial factor is a complete and correct understanding of Lean tools scope and understanding of how they should be used to achieve effective results. It is a reason why companies during each implementation invested in workshops, training and in sharing knowledge inside the organization. All employees should be aware of why company decided to implement such tools and what potential benefits can be achieved. The changes should occur

at an operational level (tool) and at a strategic level (Lean thinking) (Hines et al., 2004). Another essential step is to continuously develop Lean tools and adjust them to specific company's business needs.

Additionally:

- In company A the transformation process began from confirmation that all managers understood the organization's strategic directions, main goals and their own role in the business. Thanks to this, all employees are aware of their contribution to the identification and elimination of waste.
- In company B implementing Lean tools has a top priority. High-level managers are involved in all actions and actively participate in the preparation of the tool implementation plan and in the entire enforcement process.
- In company C there is a highly developed awareness of the main strategic assumptions among employees at all levels of the organization. Achieving this state required involvement of managers of all departments in providing information in an understandable way since the very beginning of the Lean tools implementation. Production employees are engaged and know that their contribution to the development of the organization will be appreciated.

Researchers suggest that well organized preparation stage supports achieving assumed results (White et al., 2009; Thun et al. 2010). Appropriately developed action plan with timeline of implementation is a key. Plan should include: essential steps, human resources, working time and external support. The pace of change should be adjusted to the goals and development level of the organization.

Lean and Production Managers in researched objects, confirmed that continuous improvement is possible thanks to:

- Full engagement of management board by constantly looking for alternatives to increase company results and enhance employee's skills.
- The line management plays the trigger role and can be a possible issue in the primary importance of Lean tools successful use by the organizations.
- Elaboration of appropriate workshops and training materials to enhance all employees to changes and for them to be the part of it.

In conducted studies, authors refer to identified in literature Lean success factors. In research objects it was identified like conditions supporting implementation.

Table 3.*Lean success factors identified in literature and in researched objects*

Lean Success Factors according to literature (Urban and Tochwin, 2022)	Company A	Company B	Company C
Commitment of top management	X	X	X
Training and education	X	X	X
Effective system of awards and recognitions	X		X
Concentration on production workers	X	X	
Cultural change		X	X
Data-based approach and link to business strategy			X
Lean project prioritization		X	
Precise selection of Lean tools	X		
Unidentified in research objects: Appropriate selection of the implementation team, Performance management system, Sufficient resources, Project management skills, Benchmarking system, Lean projects tracking and review, Realistic success criteria, Appropriate communication models			

Note. In table “X” means that authors identified given factor in the study.

Table 3 presents the Lean success factors identified in authors previous study. Systematic literature review was conducted (Urban, Tochwin, 2022). Authors asked Managers in research companies to indicate top 5 factors supporting implementation of Lean tools. It is interesting that Managers at all facilities confirmed that crucial elements are “commitment of top management” and “training and education”. This two factors are strongly connected. Management board should understand the training needs and give opportunities and resources to organize workshops and share Lean approach among the whole organization. Company A and C also indicates that “effective system of awards and recognition” is very important. Employees should feel that their effort and ideas are appreciated, then their engagement will increase. It is worth to add that “concentration on production workers” was also identify as an important topic by Company A and B. Production processes on shop floor level are the most important ones, since their goal is to create finished goods without defects. Company B and C indicates that if Lean effect are well known by employees then the “cultural change” is visible. After that, it is possible for the employees to achieve results they had never imagined. One of production workers said that “there are tasks I can do now that I never thought I could do before”. It is very important to understand why decisions about implementation any particular tools took place. Far too often, when employees talk about “Lean” all they have in mind is about cost savings and process improvements. Very often it is not a primary reason. It is about “cultural change” to deliver long term improvement.

6. Conclusions

This study investigates Lean tools implementation in three different automotive companies located in Poland. Research confirmed that effective results can be achieved if since the very beginning (early stage of introduction) employees are engaged in change. Lean transformation involves whole organization, all stakeholders should work with continuous improvement approach and use it in everyday activities. The vision of what would be achieved and how much is it crucial to company future success are indispensable.

Employees engagement has a huge impact on final results. It is a main reason why companies invested a lot of effort in trainings and workshops about Lean methodology. In researched companies, the strategic objectives and directions of development are understandable to all employees. Not only management, but also production line employees must to identify themselves with the designated development path of the organization. The key element is to create environment in which employees feel that they are part of the organization and have an impact on the implementation of the company's strategy. The role of line managers, the direct operators' supervisors looks to be of outstanding importance, their personal involvement as well.

The pace and sequence of Lean tools implementation is very important. They should be adjusted to identify business needs and company specificity. Process of tools implementation must be always open to modify scope of project to adjust to the current situation. Sometimes in preparation stage, it is difficult to identify all potential obstacles. Fast reaction gives the opportunity to get back on track as fast as possible. The key element is openness to employee's feedback.

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