Sustainable Lean Implementation: An Assessment Tool

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Abstract The lean management philosophy is applied to improve the productivity and customer satisfaction of an organization. Besides the manufacturing sector, where it has been a standard for a long time, it was adopted by other sectors like service, administration, and research. Though lean implementations often fail or are not sustainable. Failure reasons and success factors are named based on literature reviews. Furthermore, business models and awarding prizes for lean approaches are described and analyzed. Based on this, an assessment tool is developed. It consists of 24 criteria that are divided in the 4 categories: leadership, culture, knowledge, and process. The category culture is subdivided in: improvement, empowering, and partnering. The rating of each criterion works by interviews on the management and supervisor level, and surveys on all levels of the company. To get an objective third-party feedback, external experts can be consulted. The highest possible score is 10 and the lowest possible 1. To improve the score of low rated criteria, different countermeasures for each criterion are named. By gathering the knowledge of different research and case studies, this tool can help companies to implement lean in a sustainable way. Still it has to be considered, that every lean approach is individual and the proposed countermeasures have to be used properly. This tool is not verified in practice yet and needs of further research are mentioned as well.

Keywords Lean · Implementation · Evaluation · Assessment tool

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1 Introduction

In the past decades, lean as a process management philosophy has gained popularity in the manufacturing sector, and became a standard in large scale enterprises. During the last years, Jørgensen et al. [16] proposed that the implementation of lean increased also in small and medium-sized companies (SMEs), and the philosophy was adopted by other sectors like service, administration, and research. Bhasin [3] and Scherrer-Rathje et al. [25] discussed the goal of lean is to satisfy the customer through on time delivery and high quality products by focusing on identifying and eliminating waste throughout a product's entire value stream (including the company's supply chain network). Womack and Jones [30] defined waste as any human activity that absorbs resources but creates no value. Ohno [22] identified seven types of waste: defect, overproduction, transportation, unnecessary motion, waiting, inventory, and inappropriate processing. Later, Liker [19] added an eighth type of waste: unused employee creativity. Environmental waste is considered the ninth. Vinodh et al. [29] proposed that it embodies unnecessary or excessive usage of resources, as well as substances released to air, water or land, that could harm human health or environment.

Bhasin [3] proposed that the benefits of a lean state in a company are: shorter cycle times, shorter lead times, lower work in progress (WIP), faster response time, lower cost, greater production flexibility, higher quality, better customer service, higher revenue, higher throughput and increased profit. Scherrer-Rathje et al. [25] discussed that this is achieved through implementing a set of tools and techniques, e.g. kaizen (i.e. continuous improvement), six sigma quality, visual displays, kanban, and just-in-time supply systems. Vinodh et al. [29] and Jackson [15] proposed that a detailed description of the lean tools is provided in further literature.

Though lean is being studied extensively for more than 30 years, companies still face difficulties in the implementation of lean in a sustainable way. Scherrer-Rathje et al. [25], Liker and Rother [19], Miina [21] and Schlichting [26] discussed that question why lean implementations fail is discussed in literature. This paper focuses on finding a solution for these problems through developing an assessment tool. This tool includes countermeasures based on literature and the combination of different business models, tools/techniques and award systems.

2 Literature Review

The main problem of lean is that its implementation often fails or is not sustainable. As Bhasin and Burcher [4] state, just about 10 % of companies succeed at the implementation of lean practices. According to Pay [23] only 2 % of companies in the U.S. that have a lean program, achieved their anticipated results. Liker and Rother [19] said that even many past winners of the Shingo Prize (SP), an award for excellence in lean manufacturing, were not able to sustain their progress after winning the award.

This leads to the question why lean implementation fails or is not sustainable. Schlichting [26] for example names 7 categories of failure reasons: missing management support, lack of employee involvement, lack of customer focus, operational stability, lack of money, use of wrong tools and rapid lean conversion. Shortcomings in employee involvement and the lack of operational stability, which includes demand leveling and standard work, are regularly named as major reasons for lean implementation failures. Schlichting [26] said that experts also mention, that missing management support and a rapid lean conversion without a long-term strategy, are often responsible for problems during the lean approach. There is a lot of literature addressing this problem and offering possible solutions. Several success factors of a lean approach are mentioned in case studies and assessments. Furthermore, institutions developed business models to help companies during the implementation of lean.

2.1 Success Factors

According to Miina [21] and Liker [19] and Ohno [22] , the implementing of lean principles has to be continuous, involve multiple cycles of improvement, and can not be seen as a temporary and immediate working tool to fix problems. Consequently, the approach has to be planned step by step and every company has to have a clear vision and target about the implementation process. Liker and Rother [19] mentions that leaders have to develop people progressively by coaching them to reach a lean state.

Companies have to focus on certain steps of lean implementation process more than on others. Miina [21] proposed that these steps are named as critical success factors. Achanga et al. [1] mentioned 4 main critical success factors for a lean approach: leadership and management, finance, skills and expertise, and culture of the organization. The result of the lean implementation depends to 50 % on leadership, 30 % on finance, 10 % on organization and culture, and also 10 % on skill and expertise.

In a case study Scherrer-Rathje et al. [25] named 6 success factors for a lean approach which broadly match Schlichtings failure reasons: visible management commitment, autonomy of employees, openly disclose mid-to long-term lean goals, mechanisms for long-term sustainability of lean, communicate lean from the outset, and continual evaluation during the lean effort.

Hilton and Sohal [12] focued on success factors of lean itself and not on factors of process of implementation. Their detailed list of success factors contains: leadership, communication, behavior and awareness of Six Sigma; policies, culture and organizational support and strategy; education, training and competency of the Six Sigma experts; project improvement teams and project management; and performance evaluations based on quality criteria, information systems, data and measurement.

Beside the different success factors, there are business models that are developed to help organizations to improve their performance.

2.2 Business Models

Since most companies struggle with the implementation of lean programs, there is an increased demand for models that assist organizations to improve their performance. Most of these business models refer to the total quality management (TQM) approach, which embraces social and technical dimensions to achieve excellent results. The ideas of lean and TQM overlap in many areas and both approaches can assist each other. Duarte and Cruz-Machado [10] proposed that to facilitate the implementation of these business models, several of them are converted in awards, standards, and frameworks to analyze and assist companies during their journey to excellence. This paper focuses on the Awards. Duarte and Cruz-Machado [6] said further information about the other models can be found in literature.

Awards such as the Deming Prize (DP, in Japan), Malcolm Baldrige National Quality Award (MBNQA, in the USA), European Foundation for Quality Management-Model (EFQM-Model, in Europe), Shingo Prize (SP) and the International Standard ISO 9001 are frequently applied quality management models. While DP, MBNQA, EFQM and the ISO 9001 are based on TQM, Torielli et al. [28] proposed that the SP is designed to assess organizational lean management approaches.

Awards
In order to assess the improvement of organizations, professional institutions have developed awarding prizes to acknowledge the best practices. These prizes are based on models that provide guidelines and can be used for self-assessment during lean approaches and others. The most common models or awards worldwide are [27]:

(1) The DP, established in 1951 by the Union of Japanese Scientists and Engineers (JUSE).
(2) The MBNQA by the National Institute of Standards and Technology (USA), established in 1987.
(3) EFQM-Model, founded in 1991 as a counterpart of the MBNQA in Western Europe.
(4) The SP, established specifically for lean approaches in 1988.

Kumar [17] said that the assessment criteria differ by model: The DP for example focuses mainly on "core quality systems", while the other models focus on performance results. Duarte and Cruz-Machado [10] discussed that a detailed comparison of all models can be found in literature.

Since the EFQM-Model covers the most topics with its criteria of all TQM based awards, and the SP is especially designed for lean approaches, both models were chosen to be the basis for the tool developed in this project.

3 Assessment Tool

The objective of this paper is to develop an assessment tool that helps a company to implement lean in a sustainable way. This tool is based on the reviewed success factors, business models, and further literature. As illustrated in Table 1, the tool consists of 24 criteria which are divided in 4 categories: leadership, culture, knowledge, and process. Culture is subdivided in the subcategories: improvement, empowering, and partnering. Each criteria can be rated on a scale from 1 to 10 (10 being the highest possible score). This rating works by interviews on the management and supervisor level and surveys on all levels of the company. Additionally, external experts can be consulted for an objective third-party feedback. Furthermore, there are different countermeasures for each criterion, which can be applied if its rating is low.

Table 1 Assessment tool—Leadership

Criteria	Countermeasures
Business plans providing resources, encouragement and time for improvement	- Analyze the whole company with its stakeholders, strategic objectives, business processes and methods
	- Hoshin kanri
	- Develop lean house (how to implement lean in the company)
	- Lean accounting (focused on cost reduction)
Visible management commitment, participation and financial support	- (Weekly) management walks on floor level
	- Participation in strategic meetings
	- Include funding in business plan
Communication of the companies visions and values	- Regular info/team meetings
	- Info booklets/posters
Communication and measurement of improvement	- Pilot projects
	- Regular reviews
	- Present improvements at meetings/on posters/in newsletters
Philosophy that encourages and recognizes innovations and improvement	- Improvement culture
Employee involvement in lean approach	- Visual management (info/production boards)
	- Kaizen events
	- Job rotation ("cross-trained operator")

3.1 Leadership

The category leadership includes 6 criteria:

1. Business plans providing resources, encouragement, and time for improvement

For a successful and sustainable lean approach, it is essential that the company has clear visions and an elaborated long-term strategy. Beside the goal of every step, it has to be clear how to reach it. Resources (human, financial, and material), encouragement of employees, and enough time for improvement are important factors in the strategy. To achieve a high rating in this criterion, managers have to analyze the whole company with it stakeholders, strategic objectives, business processes, and methods. The score can be increased by the application of hoshin kanri, a method devised to capture and cement strategic goals. further information can be found in literature of Jackson [15]. By developing a lean house, the company can interpret their individual philosophy of lean in an own production system model. This concept is based on the theory that every company has its own understanding of lean and should focus on its own production philosophy. Miina [21] told that a detailed description of the lean house is available in literature. Another approach is the implementation of lean accounting where the focus lies on cost reduction, while standard accounting focuses on cost maintenance. Schlichting [26] defined that a lean accounting approach offers data that enables managers to create targets on the base of eliminating costs and track target achievement.

2. Visible management commitment, participation, and financial support

Visible and active management commitment is crucial for the success of a lean implementation. Scherrer-Rathje et al. [25] discussed that a lack of commitment may lead to a set of other issues like limited access to resources, lengthy decision-making processes, and communication breakdowns. Also, employees may not realize the importance of lean, and participating sufficiently. The importance of financial support is evident, since every change, especially an extensive one like a lean approach, is related to investments that will take some time to pay off. By weekly walks on the floor level (frequency can be reduced after lean is implemented), including conversation with the employees, the management can show their commitment and enhance the internal communication. The participation in strategic meetings is crucial to obtain information about all processes in the company and to show the importance of the approach. To ensure enough financial resources, the funding of the lean approach has to be appropriate and included in the business plan.

3. Communication of the company's visions and values

It is important that every employee of the company understands its visions and values, and identifies himself with them. It leads to an higher motivation, and changes in a process can be understood and accepted easier. In the absence of this understanding, workers could fall back to their old ways after changes, and the lean approach will not be sustainable. This can be counteracted by regular info and team meetings in

small groups, including all employees. Furthermore, the distribution or installation of info booklets and posters can improve the communication of a company's ideals.

4. Communication and measurement of improvement

The communication of lean benefits is important to motivate the employees and indorse the management in the lean approach. It is a crucial factor to convince everyone in the company that lean is the right choice, and to make sure that employees keep the new processes and do not fall back to old patterns. One way to measure and communicate the improvement trough lean, is to implement a pilot project in a small area of the company. Scherrer-Rathje et al. [25] said that the benefits can be shown very quickly, facilitating the implementation of lean in other areas. Another way to communicate the improvement, is to measure it by data in regular reviews (e.g. productivity of workspaces before and after the implementation, cost reduction, etc.) and present it at team meetings or on posters in the company. E-mail newsletters that communicate the improvement can also be applied.

5. Philosophy that encourages and recognizes innovations and improvement

An important aspect of lean is that it includes all employees. Dombrowski and Mielke [7] discussed that everyone should try to improve the process they are dealing with, since they might have the best impression of its weaknesses and failures. An improvement culture is crucial to make sure the employees feel free to develop ideas and innovations. It is based on a different understanding of failure: every failure shows possibilities for improvement and learning. The goal is to find the root cause of the failure and to make sure, it will not occur again. Furthermore, the employees need support from the management in order to maintain improvement activities at all levels and in all processes. Supervisors or Managers have to pick up the ideas and help to apply them in practice. To ensure the recognition of innovations and ideas, a recognition and reward system (see 3.2.1 in 3.2 Recognition and reward system) has to be installed.

6. Employee involvement in lean approach

The involvement of employees is a crucial factor for the success of a lean implementation. Schlichting [26] said that a lean conversion can not be implemented in a top-down manner and managers have to recognize the knowledge of their employees, and accept their input in problem solution processes. It keeps the workers motivated and enhances their contribution to the lean approach. Improvement will only be sustained, if the operators understand the reasons behind it and this can only be achieved by involving them early in the process. To improve the employee involvement, information about the lean conversion have to be made visual to the workers. Trough so called visual management, the operators will be enabled to identify and understand problems on the floor level and therefore feel the need to improve. It includes info boards with daily data, which help the employees understand the situation on the shop floor, and production boards, which shows the productivity per cell/unit and make the production numbers transparent to everybody. Additionally, kaizen events can be arranged. In these events, the operators, managers, and owners of a process come together, map the existing process, and improve it with buy-in from all parties

related to the process. Further information can be found in literature of Schlichting [26] and Jackson [15]. Trough job rotation, operators will be promoted to be "cross-trained" to work in more than one cell/process. Allwood and Lee [2] mentioned that employees will increase their knowledge and feel focused, involved, and motivated through job rotation. They will give up their daily routines which can improve their problem solving skills trough their increased involvement in the daily production problems.

Table 2 Assessment tool—Culture

	Criteria	Countermeasures
Improvement	Continuous improvement	- Kaizen and PDCA (plan-do-check-act system)
		- Systematic measurement of quality and non-quality costs
		- Use of benchmarking techniques to establish improvement standards
	Self-assessment	- Regular resumes and assessments of all processes
		- Implement self-controlling interdisciplinary teams
	Long term oriantation	- Hoshin kanri
		- Use short term measurement to support long term development
Empowering	Suggestion system	- Regular surveys
		- Suggestion meetings
		- Forms for suggestions (+ mailbox)
	Recognition and reward system	- Assessment of work processes (by shifts or workplace)
		- View the results on posters
		- Bonus system
	Formal teams (with autonomy)	- Meetings of interdisciplinary teams with autonomy to make decisions
		- Put up "decision rooms" (for team meetings)
	Employees at all levels meet with customers	- Events to connect staff with customers
Partnering	Company and suppliers or customers focus on improvement	- Regular meetings focused on improvement of interdisciplinary teams (suppliers/customers and staff)
		- Establish quality agreements
	Community, in terms of cooperative improvements	- Build up a network of different companies (competitors, companies in comparable sectors)
		- Exchange of information
		- Assessment of practices and results
		- Comparing results and discuss practices

3.2 Culture

The category culture is divided in the subcategories: improvement, empowering, and partnering. It includes 9 criteria in total (Table 2):

3.2.1 Improvement

(1) Continuous improvement
The concept of continuous improvement is crucial to keep a lean conversion sustainable and is mentioned as being the most important step in a lean journey by Miina [21] . It takes place in cycles, where a organization never stops to question its processes. A basic part of continuous improvement is to make the need for improvement visible, so it will be made with full conviction, to ensure it will take its full effect and be sustainable. Kaizen can be used to systematically detect and eliminate waste according to the Plan-Do-Check-Act-cycle (PDCA). There are different Kaizen activities, for example, value stream design, continuous improvement process workshops, periodic meetings, process reengineering, 5xWhy, or daily short stand-up meetings. A more detailed description can be found in literature of Jackson [15]. By measuring quality and non-quality cost systematically, needs for improvement can be illustrated and eliminated by using the PDCA. The use of benchmarking techniques helps to establish new improvement standards. By comparing processes, standards, or even organizations, Miina [21] proposed that improvement benefits can be made visible and they can be adopted to create new improvement standards.

(2) Self-assessment
As mentioned before, a company has to improve continuously to achieve a lean state. Self-assessments and reviewing all processes in the organization is crucial. Only by doing it regularly, mistakes or non effective processes can be eliminated and the quality of the work kept high. Scherrer-Rathje et al. [25] discussed that the implementation of self-controlling interdisciplinary teams gives a wide view from different perspectives on a process, and ensures that mistakes are found and handled in a proper way.

(3) Long term orientation
The management has to think in long term and devolve this type of thinking to the whole company. A lean approach does not always pay off financially in a short time, because every change is carried by investments. The productivity can also decrease on the short run, since the employees have to get used to the new standards. But, if an organization manages to keep lean sustainable and does not stop to believe in it, it will benefit from it on the long run. This has to be included in calculation and business plans, and everyone in the company has to be aware of it.

3.2.2 Empowering

(1)Suggestion system

To encourage the employees to be an active element in the lean conversion, and present suggestions, it has to be sure that these suggestions will be heard. If they are, the processes will be improved and the motivation of the workers will be higher, since they will feel as an important part of the company. Therefore, a suggestion system has to be established. This can be achieved by regular surveys, regarding improvement of processes, and meetings, where every employee can present his ideas and suggestions to his superior. Furthermore, there should be suggestion forms available at every workstation and a mailbox that is cleared and suggestions taken in consideration at least once a week.

(2) Recognition and reward system

Beside suggestions, good work has to be reconditioned and rewarded. In this way the employees keep their motivation and the productivity can be improved. The first step is to assess and compare the work processes, for example, by shift or workstation. The results should be presented on posters at the shop floor, to make them visible for everyone, so as to increase the motivation of each employee. A bonus system should be installed to reward good work. Losonci et al. [20] proposed that the employees of the most productive shift of a month/year can be, for example, invited to a diner or an extracurricular activity. Or each worker of the shift receives a bonus. Through this, a positive competition will be initiated, teambuilding will be supported, and the productivity of each shift or workplace will increase.

(3) Formal teams (with autonomy)

To ensure a fast decision making process, formal and interdisciplinary teams with autonomy to decide (without the need to ask a superior) should be installed. By regular meetings of these interdisciplinary teams, the problems in processes can be assessed with different points of view. Afterwards, the best solution can be found and directly implemented, without waiting days or weeks for the permission of a superior or the management. This is the most effective way to solve problems and increase the productivity. To encourage this process, "decision rooms" for these meetings can be put up.

(4) Employees at all levels meet with customers

Lean focuses on the customer. To enable this, a company has to know the customer and their needs in detail. Beside the management, which is usually in contact with the customers, every employee should meet the customers if possible. Events to connect the staff with customers can be arranged or different employees can be sent to fairs. This ensures that the workers know the needs of the customers and can use this knowledge to improve processes.

3.2.3 Partnering

(1) Company and suppliers/customers focus on improvement
To achieve a high productivity, a company has to work together with its suppliers and customers. As mentioned before, the needs of the customer have to be known by the company. In the same way the supplier needs to know the needs of the company. By cooperation, focused on improvement, the efficiency can be increased on both or all three sides. Regular meetings of interdisciplinary teams (of both or all three parties) ensure the exchange of knowledge and increase communication. Even special topics and problems can be discussed since the teams are interdisciplinary and know the subject matter. Based on these meetings, quality agreements should be established to ensure that the outcomes will be sustainable.

(2) Community, in terms of cooperative improvements
Knowledge is one of the most important factors to achieve improvement. By sharing information, practices, and experience with other companies that have similar processes, problems and mistakes that occur on the way to improvement can be avoided. Therefore, it is helpful to build up a community, for example, with competitors or companies in comparable sectors and exchange information and knowledge with them. To find the best method, the different practices and their results should be assessed, compared, and discussed.

3.3 Knowledge

The category knowledge includes 4 criteria (Table 3):

1. Skill of management
The management and its skill is crucial for a lean approach. It has to lead and motivate all employees. Dombrowski and Mielke [8] mentioned lean leadership as a way to make a lean implementation sustainable. For achieving this, the managers have to develop themselves over years and have a deep knowledge about the whole company with all of its processes. To get the skills necessary for becoming a good leader, managers can participate in workshops and trainings. Furthermore, self-improvement can be achieved by self-reflection and literature study.

2. Knowledge of and experiences with lean practices
A deep knowledge about lean and experiences with lean practices on the management level, are obligatory for a sustainable lean approach. It is necessary to make the right decisions at the right time, and choose the suitable tools. If the knowledge or experiences is not given, external experts can be hired to assist during the lean approach. Taking into consideration that this help is temporary, managers have to participate in workshops and trainings to improve in this field. Additionally, lean literature should be studied and applied in consultation with the external experts.

3. Skill of workforce/Training and improvement

Beside the management, also all employees of the company need to have the necessary skills to implement lean and apply the lean tools. The skill of workforce is another crucial factor, beside their motivation and understanding of the lean effort and its benefits. Even if the workers want to apply the changes of the lean program, it will not be sustainable if they do not have the necessary knowledge and capabilities. The employees are expected to conduct the lean program, for example, by the use of problem-solving skills, which requires long-term employee development. This can only be achieved through daily development by coaching, and as far as possible, every employee should be developed at its individual level. Dombrowski and Mielke [8] showed that these trainings should take place in short cycles based on PDCA. Workers should be encouraged to learn from each other. This can be accomplished by monthly communication meetings with workers from the same workplace or overlapping shifts, where workers can exchange their knowledge and practical experiences at a workstation. The development of employees is a never ending process, and the trainings have to be continuous as well. Knowledge and skills should be regularly reviewed to assess improvement and identify the training topic in need. A small leader-to-employee ratio ensures that every worker will be developed in a proper manner, because the leaders can pay attention to each single employee. Dombrowski and Mielke [8] recommend a ratio of 1:5 at operational level, while it can be up to 1:10 at higher levels.

3.4 Process

The category process includes 5 criteria (Table 4):

1. Systematic identification and elimination of all types of waste

Table 3 Assessment tool—Knowledge

Criteria	Countermeasures
Skill of managagement	- Deep knowledge about all company processes
	- Trainings and workshops
	- Self-improvement (literature)
Knowledge of and experiences with lean practices	- External experts
	- Trainings and workshops
	- Self-improvement (literature)
Skill of workforce	- Specific quality trainings and workshops (in short cycles)
	- Encourage employees to learn from each other
Training and improvement	- Review of knowledge and skills
	- Small leader-to-employee ratio

Table 4 Assessment tool—Process

Criteria	Countermeasures
Systematic identification and elimination of all types of waste	- Comprehensive documentation about work methods and organizational processes
	- Quality manuals and organizational processes are periodically revised
	- Systems of indicators are in place to revise changes in processes
Standardization of processes	- Meetings with workers to find the best process
	- Training/poster of the standardized processes
	- Check if the standardized process is applied
Cellular process arrangement and improvement	- Analysis of workflow and workplace disposal
Just-in-time (JIT)	- Fast, continuous and steady flow of information across all value streams
	- Pull system (customer orientation)
	- Simultaneous engineering
	- Quick changeover
Automation (Jidoka) and multiprocess handling	- Analysis of processes focused on opportunities for automation
	- In-station quality control
	- Andon line

As mentioned before, the nine types of waste are: over production, unnecessary stock, inefficient transportation, unnecessary motion, waiting times, rejects & defects, inappropriate processing. The basic idea behind lean is to eliminate all of them. Therefore, they have to be identified systematically in a process. Bou-Llusar et al. [5] said that all work methods and organizational processes have to be comprehensively documented and verified. Furthermore, all quality manuals and organizational processes have to be periodically revised, to keep the processes at its highest level. If a waste is identified, there have to be changes made in the process. These changes can be suggested by employees, found in literature, or developed in special meetings. After this changes are implemented by teaching the employees and placement of manuals at the workstations, they have to be made sustainable and reviewed regularly. A system of indicators should be installed to check if unwanted changes are made in a process.

2. Standardization of processes

Duarte and Cruz-Machado [10] said that the standardization of processes is one of the basics of lean and represents control of the process, constructing the process as simply as possible. It reduces improvisation or ineffective actions, makes work easier, and provides security. Dombrowski and Zahn [9] said that "standardization in the context of working standards means that specific methods (e.g. construction methods) have to be standardized, coordinated with suppliers, and be state of the

art". To define standards, the best possible process has to be found. This can be made in meetings with workers, since they know their workplace and the process best. The implementation of new standards can be conducted by training the affected employees, and installation of posters of the standardized process to ensure it stays in the mind of the workers. Moreover, there should be reviews to check if the standardized process is applied.

3. Cellular process arrangement and improvement

Cellular manufacturing is a workplace design model, which takes advantage of the similarity between parts or processes. Similar machines are placed close together or machines are grouped together, according to the similarity of the parts produced. Bhasin and Burcher [4] discussed that Processes are more robust to machine breakdowns, the material flow improves (reduce of transport, waiting and process times), and lead times are reduced. To be able to implement a cellular process arrangement and improvement, Irani [14] proposed that the workflow has to be analyzed first. After this, the workplaces can be organized according to cellular manufacturing principles which can be found in literature.

4. Just-in-time (JIT)

JIT is one of the two pillars of the Toyota Production System (TPS), which is the system lean management is based on. Cruz [6] said that it reduces the inner waste of resources with the smallest investment achieving the biggest output. Santos [24] proposed that its main objective is to produce the required number at the moment the customer orders it (customer orientation). According to Haak [11], JIT means, the parts needed reach the next processes step at the time they are needed in a flow process. Furthermore, it is mentioned that a company which established this flow throughout can approach zero inventory. It is obligatory to have a fast, continuous and steady flow of information across all value streams, to be able to deliver the right item at the right time. A pull system helps to deliver only what the internal customer orders, by scheduling each step in the development process, and dividing the whole process into uniform working phases. Another method is simultaneous engineering (SE), where fixed contact persons in every department are responsible to ensure the parallelization of tasks. Dombrowski and Zahn [9] discussed that detailed information about the different methods can be found in literature. Quick changeover is a concept to reduce the downtime of equipment. Therefore, it can maintain the JIT process. It enables a company to produce small volumes of a large variety of products while still maintaining the advantages of mass production. Further information are provided in literature of Horbal et al. [13].

5. Automation (Jidoka) and multiprocess handling

The other pillar of the TPS is Jidoka, which can be translated as automation. It includes the concept of automation and of autonomous monitoring for defects and elimination of their causes. Every process has to be analyzed on opportunities for automation, and if it is possible and useful, the process should be automatized. Since a defect can cause an immediate standstill of the machines in automated processes, Haak [11] proposed that the production workers have to be in a position to find the

defect as soon as possible and fix it to minimize the production down time (in-station quality control). Schlichting [26] said that the so called Andon line, allows employees to call for help if they notice a problem and even stop the production line if the problem can not be solved directly. Multiprocess handling means that one operator works across several machines in one process, rather than have different operators. Since the product will flow with the operator, the workflow will be constant. There can be more operators working across several machines and following each other with their own work piece.

4 Discussion and Conclusion

The purpose of this paper is to develop an assessment tool that helps an organization to implement lean in a sustainable way. Initially, the success factors of a lean approach have been identified and different business models have been reviewed. The research has shown that there are 4 main categories of crucial factors (leadership, culture, knowledge and process), including 24 criteria in total. Based on the literature, different countermeasures were chosen for each criteria. A company can rate the criteria to reveal its needs for improvement, and react immediately by applying the respective countermeasures. This tool gathers a lot of knowledge and information, by combining various findings of different research and case studies. It helps organizations to implement lean, but the management has to be aware, that every lean approach is individual. The conditions and environment change from company to company, thus the proper use of the proposed countermeasures.

The limitations of this developed tool, are related to the lack of experience. Though the tool is partly based on case studies and assessments, it is still a theoretical approach and it has not been verified in practice. Further research is necessary to analyze the impact of this tool on lean implementations. Additionally, focus could be placed on the rating, and a model to measure the value of a criterion could be developed.

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