Road Map for the Implementation of Lean production tools in SMEs

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Abstract— SMEs play a critical role in the sustenance of national economics worldwide. However, these companies are facing enormous challenges and complexities caused by the competitive environment in which they are operating. Therefore, SMEs are attempting to engage new approaches like lean production in order to enhance their performance. However, it is well documented that a very few number of SMEs have been given the opportunity to benefit from competitive advantages gained by lean production. Many researchers have stated that the failure of Lean production implementation in SMEs is, generally, due to: the use of wrong tool, the use of one tool to solve all the problems, the lack of understanding, and the poor decision-making. Although many models and frameworks exist in the literature, a little has been developed based on SMEs’ specifications and contained suitable tools for them to implement lean production properly. This is why the present paper aims to provide a systematic roadmap that contains the most suitable lean tools for SMEs. This roadmap was developed through case studies of five SMEs that were implementing lean in their production systems.

Keywords— Lean production; implementation; roadmap; Small to Medium sized Enterprises

I. INTRODUCTION

Lean production is one of the initiatives that many companies around the world have been trying to adopt in order to streamline the production process and achieve optimization in resources [1, 2]. The concept of lean production includes a set of tools and practices striving to gain competitive advantages by increasing production capacity [3], enhancing products quality [4] and reducing lead time [5]. This is achieved by eliminating waste in the system [6]. The Lean philosophy aims, therefore, to identify and eradicate the non-value added processes or “waste” as viewed by the customer [7], then, to optimize the use of resources and build a continuous corporate culture that leads to customer satisfaction [2]. This philosophy is based on five principles [8]: (1) specify Value as perceived by the Customer, (2) identify the Value Stream, (3) make the Value Flow through the Value Stream, (4) Pull the Value from the Value Stream, (5) Strive for Perfection. These principles were widely accepted in different type of organizations seeking to improve their performance in order to keep their competitiveness in the current economic context of globalization and great competition.

On the other hand, Small to Medium-sized Enterprises (SMEs) are valued as an important driving force behind the international economy, because of their crucial role in the international economic development, typically accounting for over 90% of business establishments and about half or more of output and export shares [9]. Also, these companies play a tremendous role in the employment generation. Pingyu and Yu [9] proved that SMEs account for as much as 70% of the labor force in many developing countries. For these reasons, many researchers have promoted the idea of applying lean production within SMEs as condition of the international economic growth. Moreover, SMEs have also felt the pressure exerted by the market and sought to improve their performance by engaging themselves in lean programs.

Unfortunately, a very few number of SMEs have succeed to implement properly lean production and benefit from its outcomes [9, 10, 11]. Rose et al. [12] stated that the main reasons for failure of lean production implementation in SMEs are: use of wrong tool, use of one tool to solve all the problems, use of the same set of tools to solve problems and lack of understanding. The problem of the use of lean tools and practices in SMEs has a relatively short history. According to Zhou [7], very few studies regarding lean tools application in SMEs have been done in the past, a thorough research needs to be carried out so as to gauge how SMEs can adapt to these practices and apply them. Identifying accurately which tool/ practice is
needed to be applied and when, will be very useful for SMEs. Actually they will be able to make effective decisions during lean implementation planning, and then to maximize their benefits from lean practices.

For these reasons and with the aim of assisting SMEs to implement properly lean production tools, this article proposes a roadmap which is believed to be suitable and useful for them. This roadmap is resulting from the successful experiences of five SMEs that are including lean in their production system presented as case studies. The resulting roadmap contains the most suitable lean tools and proposes the optimal sequence of their implementation in order to guarantee a successful lean production implementation in SMEs.

The organization of this paper is as follows. After the introduction, Section II presents the different aims and objectives of the research as well as the methodology perused to fulfill these objectives. Section III is also divided on two parts. First, each of the case studies is presented individually. Then, the proposed lean implementation roadmap including suitable tools and optimal sequences of their implementation has been discussed in the following part. Finally the conclusions containing a summary of the essential results of the paper and suggestions for further researches are presented.

II. RESEARCH OBJECTIVES AND METHODOLOGY

A. Research problem and objectives

Although they are developed based on large companies, most of lean production tools and practices are widely applicable in SMEs [13]. This point of view is supported by more than a researcher. For example, White et al. [14] argued that lean and JIT practices are as beneficial for SMEs as for large companies. They even proved that some lean tools such as multifunctional teams and total productive maintenance have more chance to succeed in SMEs. This is approved, also, by Lee [15] who suggested that some aspects of small firms actually present advantages for JIT or lean practices in small firms.

Even though SMEs have the potential to success in lean implementation, many researchers have found a negative correlation between organization size and degree of lean practices implementation [14, 16]. This is justified by the fact that smaller enterprises are less ready to implement a wide variety of lean practices due to several barriers and obstacles that facing SMEs. One of the principal obstacles is the poor decision-making about which tool to apply and when. Many researchers prove that this obstacle can manifest in three forms: use of wrong tool, use of one tool to solve all the problems and use of the same set of tools to solve problems [10, 12].

This problem indicates that there is a real need for guidelines as a roadmap that specifies the optimal sequences of lean tools to implement in SMEs. This roadmap will constitute a real base on which SMEs will rely to maximize their benefits from lean tools and practices outcomes. To achieve the aims of this research, three objectives were fixed:

- Identify which lean production tools are being implemented in different types of SMEs,
- To investigate, via case studies, the sequences of the implementation of these lean tools for different types of SMEs,
- To develop a generic roadmap for lean tools implementation in SMEs containing the suitable tools and the optimal sequences of their implementation.

B. Research methodology

The present article aims to provide for SMEs a more meaningful and effective path for implementing lean tools and practices. This path will be presented in the form of a roadmap that contains tools and the optimal sequences of their implementation. Then, it will contribute to resolve the issue of the poor decision-making when elaborating lean programs for SMEs. For that, three objectives were developed as shown in the previous section. To fulfill the aims of this research, it was felt that case studies [17, 18] provided the best strategy, because as Voss et al. [19] reported, case studies are not only good at providing answers to how and why questions, but also suitable for developing new theory and ideas. Moreover, conducting multiple case studies is identical to reproducing experience, and then the results are often valued more convincing [20]. Therefore, it was decided to take this approach. Figure 1 shows the research methodology pursued.
Primary, a database of SMEs (less than 150 employees and 50 million £) was created based on “LinkedIn”. This database contained the main contacts of 65 SMEs around the world (corporate name, geographical location, e-mail address and phone number). Afterwards, a first contact is established with companies to get the contact person who is one of the key persons responsible of lean implementation. This person is contacted later by e-mail and phone. Five of them accepted to participate in the study. For these SMEs, interviews were arranged with a manager or a lean engineer. The main details of these SMEs are presented in Table I. For reasons of confidentiality, SMEs are symbolized by A-E.

### Table I. The main details of SMEs participated in the study

<table>
<thead>
<tr>
<th>Company</th>
<th>Activities</th>
<th>Volume of production</th>
<th>Type of products</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Automotive supplier</td>
<td>Low</td>
<td>Multiple standards products</td>
</tr>
<tr>
<td>B</td>
<td>Chemical industry</td>
<td>High</td>
<td>One standard product</td>
</tr>
<tr>
<td>C</td>
<td>Textile industry</td>
<td>High</td>
<td>Multiple standards products</td>
</tr>
<tr>
<td>D</td>
<td>Metal construction</td>
<td>Low</td>
<td>Specific products</td>
</tr>
<tr>
<td>E</td>
<td>Electrical equipment</td>
<td>High</td>
<td>One standard products</td>
</tr>
</tbody>
</table>

Companies participated in the study have different characteristics. This comprises both discrete and continuous industries and companies with high and low volume of production and variety of products. This helped to get an overall overview allowing to propose a dynamic roadmap that suggests for each type of SMEs the most suitable set of lean tools to implement.

### III. Development of the Lean Tools Implementation Roadmap

As described in the previous section, the aim of this research is to capitalize on the experiences of a number of SMEs from different types that have successfully integrated lean in their organizations in order to construct a dynamic roadmap that will be suitable to implement in all types of SMEs. Abbreviations and Acronyms

#### A. Description and analysis of the different sequences of lean tools implementation

The first step of the construction of the roadmap was the investigation of the sequences of lean tools implementation for different types of SMEs. To fulfill this objective, companies described above were investigated through interviews carried out with their managers. The following is a review of the different sequences of lean tools implementation in these SMEs.

1) Case studies

a) Case study A

Company A is a small automotive supplier specializing in the acoustic environment of the vehicle. It possess a semi-automatic production process that performs three types of standard products: cushions and headrests, coverings and plastic automobile components and carpeted floor mats for the interior and trunk. In 2010, the company found that the process was producing three times more waste than the expected objective. Therefore, the company has decided to introduce lean production in its production process via a subset of lean tools.

Implementation started with a step of house organization via 5S program and cellular manufacturing implementation in order to create a continuous flow and reduce the waiting waste. Once this “build step” was closed, the company has engaged in the “implementation step”. At this step, a set of pilot projects was implemented depending on strategic goals of the company:

- Quality project with the goal of increasing products quality and reducing the number of client claims. This project involves the implantation of a quality control program.
- Just in Time project with the goal of reducing lead time. A SMED program was engaged to reduce the long changeover time giving the variety of products.
- Reliability project that comprises a Total Productive maintenance (TPM) program.

The consequent improvement was progressive and took over 6 months to take effect. However, Company A felt the reduction of waste even beyond their expectations as a result of the implementation of lean tools. Therefore, the company would like to sustain these results by establishing work standards.

b) Case study B

The second company interviewed is a medium sized enterprise that operates in chemical industry. It has an automatic process that produces a standard product which is a type of fertilizers. Over the previous decade, the company has witnessed many changes. These include the obtaining of ISO 9001 certification and the implementation of lean program. The lean program has covered the whole process and has improve significantly the economic performance of the company.
The sequence of lean tools implementation in this company is different from that of the company A. This company have begun with seeing and mapping its process using the Value Stream Mapping (VSM). This allowed to locate wastes within the process and then to implement a set of tools to eradicate this wastes. This begun with a 5S program to organize the workplace and eliminate waiting wastes followed by a TPM program to ensure maximum availability of production facilities. The program was ended by a step of locking and generalization using Kaizen and work standards.

c) Case study C
The third company is a small textile mill, with under 100 workers, performing a variety of yarn types for commodity consumption. For this case, the sequence of implementation of lean tools has begun with the implementation of VSM (like Company B) to oversee wastes in the process. Then a program of initial organization that includes the implementation of 5S and cellular manufacturing was initiated. This was followed by the implementation of pilot projects that include:

- SMED project giving the variety of the products,
- Kanban project to operate with pull flow.

At the end of the lean program, the company established work standards to generalize the results of pilot projects.

d) Case study D
The fourth company is a metal constructor. It possess an automatic process that produces specific products. The company attempted to implement lean twice during the early 2000s. However, both attempts were ignored due to their failure to achieve desired results caused by the non-appropriate use of lean tools especially with the specific characteristic of its process. Despite this, the company later found the optimal methodology to successfully implement lean program in 2012.

The lean program has begun this time by the VSM that revealed that the primary sources of wastes were the insufficient utilization of facility and quality defect. Therefore, an action plan was implemented. This comprises:

- 5S and TPM to increase the process utilization and efficiency,
- Total Quality control to ensure a high quality of products.

This action plan were accompanied by the deployment of a problem solving culture based of the Kaizen spirit in order to sustain the project results.

e) Case study E
The last company interviewed is a small electrical enterprise. It is an automotive supplier that produces a type of car batteries. The production process of the company is totally automatic and produces a high volume of production. Because of the great competition in the automotive market, the company has a great interest in lean and other success improving approaches. This derived from the increasing requirement of clients for flexibility and shortened lead times while still demanding extreme products quality. The company, therefore, engaged in a lean implantation project in 2011.

It started with 5S including visual management. Also, the workplace is arranged in cellular manufacturing to promote the one piece flow. In the second step, a TPM program is launched because the company was needed to improve its productivity in order to satisfy the high demand of their customers. At the end of the project, the company felt important to establish work standards and to deploy a problem of detection and solving of the problems to boost the lean approach.

2) Summary
In a nutshell, the interviewed companies have all implemented lean successfully in their production processes. However, they have not implemented the same lean tools. Also the sequences of the implementation are not similar. Thus, it is important to group these tools in generic steps in order to find the optimal implementation sequence. For that, the tools that are simultaneously implemented in each case are grouped in one step symbolized by a number. The results are given in Table II.

<table>
<thead>
<tr>
<th>Lean tools/ practices</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>5S and Housekeeping</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Value Stream mapping (VSM)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pull system/ Kanban</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>SMED</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cellular Manufacturing</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality control</td>
<td>2</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total productive maintenance (TPM)</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Standard Work</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Kaizen and problem solving</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
According to Table II, sequences of lean tools implementation in the interviewed SMEs include in general four steps (except companies A and E who have missed the first step):

- Step 1 comprises VSM,
- Step 2 comprises 5S and cellular manufacturing,
- Step 3 comprises Kanban, SMED, Quality control and TPM,
- Step 4 comprises Standard work and Kaizen.

All the companies have successfully implemented lean program. However, none of the companies interviewed possess the optimal sequence of lean tools implementation. For example, companies A and E have missed the very important step of mapping their processes. Also, Companies A, B, D and E have not implemented a pull system that is essential to work with Just in Time. In turn company C have not relayed on a problem solving culture to sustain and generalize the results achieved. For this reasons, the integration of all the sequences is important in order to develop a new roadmap that contains the strengths and fills the gaps of each sequence.

B. Proposed Roadmap for lean tools implementation in SMEs

1) Description of the proposed roadmap

The ultimate objective of this research concerns the proposition of a roadmap which contains the optimal sequences of lean implementation in SMEs. Based on the experiences of five SMEs that are successfully integrated lean in their production process, the authors have developed a roadmap that summarizes the strengths of the sequences perused by these companies. Step by step description of the roadmap is provided in Figure 2 as the following.

The roadmap developed contains four steps:

a) Map the process

This is the first step consisting on seeing the overall production process. Indeed, SMEs need to oversee their value streams and locate the different form of wastes. The recommended and suitable tool for SMEs to approach the entire process flow is the Value Stream Mapping (VSM). VSM includes a variety of other lean practices that are suitable for SMEs i.e. visual control, time study, seven Mudas …etc. the output of this step is the representation of all the existing wastes and the design of the desired situation of the process.

b) Organize the house

This constitute the “warming up step” in which a set of foundations must, first, take place to enable the deployment of other lean practices. First, 5S has to be a fundamental part of the lean implementation efforts in SMEs. Because as Lee [21] reported is less financial investment and easy to implement is SMEs. In addition, this fundamental tool involves a variety of lean practices such as employees’ involvement and commitment and visual management. At the same time, SMEs need to build a Just in Time culture through the arrangement of the work stations in cellular manufacturing. This promote the continuous flow and increase the flexibility of the process.
c) Improve the process

This is the main step in the implementation process of lean tools. In this step, a set of lean pilot projects based on specific lean tools are suggested to be implemented to create a prototype or a trial implementation. The objective of the pilot project is to ensure that any expansion of lean implementation is based on the accuracy, effectiveness and efficiency [22]. Each pilot project relay on a lean tool that should be carefully chosen depending to the type of SMEs. This type is, as Wan and Chen [23] suggest defined depending on two dimensions i.e. the volume of production and the repetitiveness of products. Figure 3 proposes a guidelines for decision of selecting tool that help define suitable tools of each type of SMEs.

According to Figure 3, tools of the previous step are (VSM, 5S and cellular manufacturing) in addition to Quality Control are universally applicable in all types of SMEs, while the applicability of the other lean tools depends on SMEs type. TPM is applicable when the volume of production is high. Actually, SMEs need to enhance their productivity and then their equipment’s effectiveness. In addition, in the case of high volume of production and low repetitiveness of products (high variety of products) SMEs are recommended to apply also Kanban to work with pull flow. Finally, SMED is recommended to reduce changeover time when producing a variety of products (low repetitiveness).

d) Sustain the results

This is the final step recording the new way to do tasks and culture changes resulted during lean project. In this step, it might be worthwhile for SMEs to capitalize on their own experiences by establishing the new work standards and planning of continuous improvement based on the problem solving and Kaizen culture to facilitate the future utilization of these practices.

2) Confirmation of the proposed roadmap

For the purpose of confirming the applicability and the usefulness of the roadmap developed above, it felt that is important to confront this roadmap with a set of criteria proposed by Yusof and Aspinwal [24] in order to approve the proposed roadmap suits really the SMEs characteristics. These criteria are [24, 25]:

- Systematic and easily understood,
- Simple in structure,
- Having clear links between the elements or steps outlined,
- General enough to suit different contexts,
- Represent a road map and a planning tool for implementation,
- Answers “how to?” and not “what is?”,

Implementable.

Based on these criteria, it was found that the proposed roadmap suits considerably the SMEs features. Following are the main characteristics of the proposed roadmap, which set it compliant with these criteria:
This roadmap includes common known tools such as VSM, 5S, SMED … etc. Moreover, it is self-explanatory and comprehensible for SMEs without any difficulties. Consequently, it is clear that the roadmap satisfy the first criterion “Systematic and easily understood”,

The structure of the roadmap is very simple including four steps which are clearly distinguished. That is why this roadmap meets clearly the second criterion “Simple in structure”,

The roadmap provides a very explicit relationship between the various steps and tools through a logical implementation sequence. Therefore, the third criterion “Having clear links between the elements or steps outlined” is largely satisfied,

Different types of SMEs can apply the roadmap. All they have to do is determine the type of their production process according to the two dimensions described above. Then they can easily determine suitable tools to implement. For this reasons, it is approved that the roadmap meet the fourth criterion “General enough to suit different contexts”,

The basic idea for this roadmap is to propose the optimal sequence of the implantation of lean tools in SMEs. Hence, the satisfaction of the criterion of “Represent a road map and a planning tool for implementation” is obvious,

The central aim of the roadmap is to give an effective answer for the issue of how can SMEs introduce lean tools and practice effectively in their production process. Then, it is clear that it answers “how to?” and not “what is?”

The roadmap includes a set of tools that are suitable and implementable in SMEs. These tools are proven both by the successful experiences of the five SMEs investigated and by the affirmation of several authors [26, 7, 27]. Thus, the proposed roadmap meets the criterion of “Implementable”.

In short, the proposed roadmap is applicable to SMEs in different types, since it provides practical guidance for the introduction of lean tools and practices in a very specific type of organizations such as SMEs.

IV. CONCLUSIONS

Many advanced enhancement approaches including lean implementation are mostly adopted by large companies. However, SMEs was left behind although they have a very important potential to support the international economy. In most cases, they are not given the focus they merit. However, and with the context of globalization and technologies emergences, SMEs were putted in a very insecure position that require them to engage in approaches such as lean in order to keep their survival.

With the view of assisting SMEs to introduce effectively lean programs, the central aim of this paper is the development of a roadmap of implementation of lean tools. This is achieved through case studies conducted in five small and medium sized enterprises operating in different areas and having different characteristics of production processes. The focus has been the optimal sequences of lean tools implementation in the different SMEs. The outcome was a generic roadmap that contains the most suitable tools for SMEs and the optimal sequence of their introduction. The proposed roadmap has a simple structure including nine tools and four steps to accomplish the lean implementation. This roadmap is confirmed as suitable to SMEs because of its satisfaction of a set of criteria recommended by several authors.

Although it is developed based on the individual experiences of five SMEs, the presented roadmap makes a significant contribution for the different reasons:

First, it provides a solution of the scientific problematic of the poor decision making of the choice of lean tools to implement when elaborating lean programs in SMEs. This problematic was arisen by different authors and remains unanswered,

Second, it highlights the successful experiences of SMEs in implementing lean programs and then proves that lean can give a relevant result even for small companies,

Finally, it provides the basic framework for developing generic model for lean implementation in SMEs including all the other concepts, principles and success factors in addition to lean practices and tools.

The roadmap can be further improved by following efforts. First, it needs to be validated by its effective implementation in different types of SMEs. This will led to add new tools to the roadmap while maintaining its logic. Finally, and because lean is not only a set of tools, practices and techniques, but also a journey about “lean” thinking, culture change and continuous striving for perfection, this roadmap can be a part of a global model of lean implementation within SMEs that will includes all lean thinking concept and principles.
REFERENCES


BIOGRAPHY

Belhadi Amine is basically an Industrial Engineer. He works currently as production and process engineer in chemical sector. After graduated from The National School of Applied Sciences (Safi) in 2013, he became member in the Industrial Engineering Research Team at Higher School of Technology (Safi), Cadi Ayyad University subsidiary. His expertise area is the Industrial Engineering particularly Lean Manufacturing. He has participated in lean programs implementation in many companies.