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ORIGINAL ARTICLE

Exploring Lean Production System Adoption in the Moroccan Manufacturing and Non-Manufacturing Industries: Awareness, Benefits and Barriers

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ABSTRACT – Although lean manufacturing emerged in the 1990s, and since then, it has become known and recognised worldwide, companies still struggle to implement it successfully, especially in less developed countries. The purpose of this paper is to assess the level of maturity of lean production within small and medium-sized companies, identify what the benefits of lean implementation are, and present an exploration and analysis of the barriers that influence the implementation of lean production in these companies.To achieve this objective, items from previous studies were extracted through a systematic literature review and then validated by interviews with Moroccan experts in the manufacturing and non-manufacturing industry; on the other hand, a questionnaire survey was conducted with 78 small and medium enterprises in Morocco. Subsequently, all collected responses were statistically analysed using Statistical Package for Social Sciences (SPSS V21.0). The results show that the lean approach is unfortunately not yet adopted and applied by all Moroccan SMEs (24% of our respondents have not yet tried to apply lean). In addition, the most significant benefits announced by Moroccan small and medium enterprises are 'the elimination of waste (82.1%)', 'the reduction of costs (78.2%)', and 'the improvement of efficiency and performance of production units (70.5%)'. Finally, the principal component analysis indicated that the two main difficulties that need to be maintained are poor management (with 63.6 % of the total variance) and lack of financial resources, monitoring, and skilled labours (with 7.7 % of the total variance).

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INTRODUCTION

The concept of 'lean manufacturing' is considered to be the most important revolution among all organisational modes; bringing significant contributions to the company, improving performance in terms of safety, lead time, quality, cost, improving the ergonomics of workstations, working conditions, and employee involvement [1-3]. And for quite some time now, companies in developed countries have been implementing it, and today it is present even in less developed countries. In this sense, all these countries have observed spectacular successes thanks to this management system, but on the other hand, these companies have encountered many difficulties that have led them to failure. Morocco is not an exception, several Moroccan organisations have applied lean in their companies and they have been able to make significant improvements. For example, in a company specialising in industrial thermo-mechanical processes, Tajri and Cherkaoui in 2015 were able to increase the value of the synthetic yield rate by 34% by applying the lean concept. They improved the overall efficiency of the equipment (OEE), and they were able to reduce the time of change of series by 16% [4]. Similarly, in the field of construction and public works in 2017, Bajjou. et al. [5] indicated that lean improves the quality of projects, reduces costs, and increases the environmental performance of construction projects.

The main objective of this paper is to assess the level of maturity of lean production in Moroccan small and medium enterprises, identify the benefits of lean, and analyse the difficulties encountered by these SMEs when deploying lean. We have chosen SMEs because they play an important role in the Moroccan economic development strategy. According to the results of the national survey conducted by the High Commission for Planning (HCP) among 2101 companies in Morocco in 2019 [6], it was found that the structure of companies is 93% very small and medium enterprises (VSE 64% and SMEs 29%), they have significant importance in the economic fabric of the country and they occupy more than 50% of employees in the private sector [7], against 7% of large enterprises (GE).

Generally, investigations to explore the Moroccan context concerning the level of maturity, expected benefits, and barriers to implementation are absent and limited. Therefore, this study aims to overcome this research gap and bring answers to the following research questions: (a) what is the level of maturity of the deployment of the Lean Manufacturing concept at the national level? (b) what are the benefits that can be derived from the implementation of the LM? and (c) what are the critical barriers limiting the successful implementation of this approach? This study will provide important first-hand information on the current state of lean implementation in Moroccan enterprises. The results of this research should be taken into account by the top management of the organisations, whether in Morocco or other countries. Furthermore, these results could even help academics, practitioners and researchers who are actively interested in the

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same field, to enrich their knowledge, develop more studies and look for solutions to help a successful implementation of lean.

LITERATURE REVIEW

Lean manufacturing was introduced in Toyota plants in the 1970s [8]. The basic idea of lean is to maximise customer value by minimising waste; lean simply means giving more value to the customer by using fewer resources. It is not just a method or a cost reduction approach but a way of thinking, a work philosophy, and a continuous improvement process that integrates all company personnel to eliminate or reduce waste in manufacturing processes. According to Taïchi Ohno [9], the founder of the Toyota Production System, the seven sources of waste are:

i. Overproduction: Producing more than the customer needs or producing before the order.
ii. Stockpiling: This is waste caused by overproduction, waiting times, and poor planning.
iii. Unnecessary transport and travel: Moving materials, parts, products, documents, or information that do not add value.
iv. Unnecessary processing or over-processing: Tasks, steps taken for nothing, and processes that are too complex for the price of the sale.
v. Unnecessary movements: Unnecessary physical movements of people that do not bring value to the customer and that are caused by poor workstation ergonomics.
vi. Errors, defects and rejects: These are defects that require reworking, additional inspection, disposal, customer dissatisfaction, etc.
vii. Waiting times: These are the times of the series changeover that are too long and also the products or people who have to wait between two tasks or steps.

Several authors [10-12] have added to the original 7 wastes, an 8th waste, which is the underutilisation of skills: human potential is too often underutilised in companies. Through employee involvement and continuous improvement, there is a huge capacity to reduce product defects.

Companies use employees as labour but forget that they can be a great source of improvement by encouraging them to suggest improvements and to express themselves about their work. Only by leveraging employee creativity can companies eliminate MUDA and improve performance. For example, lack of training, rigid and authoritarian management, low motivation, recognition and involvement lead to an under-utilisation of employees' skills. These wastes are directly transformed into inventories, thus into cash outstanding, customer delays, customer satisfaction and market losses. Therefore, they are a formidable source of improvement in the system's overall performance.

Lean Benefits

By implementing lean, many SMEs have been able to achieve advantages and benefits, as shown in Table 1. In the United Arab Emirates, Alefari et al. in 2020 evaluated the status of lean using a questionnaire survey, and they concluded that the main benefit of lean implementation is the increase and acquisition of new markets [13], and this was confirmed even by Almanei et al. in the United Kingdom [14], in contrast to the study of Belhadi et al. who conducted a questionnaire survey among SMEs in North Africa [15]. The results of this study showed that improving competitiveness and opening up new markets do not provide significant advantages or benefits for lean implementation in these SMEs. On the other hand, it was found that the most significant benefits reported by the SMEs surveyed were: reduction of waste with an average of 4.04; decrease in delivery time (3.58); improvement in customer satisfaction (3.56), and finally culture change (3.35). In another research, Belhadi et al. in 2018 conducted a case study, an SME specialised in the production of a wide range of industrial pumps such as (centrifugal pumps, multistage submersible pumps, jaws, and valves) and located in North Africa, they concluded that by adopting lean practices (5S, SMED, Kanban, VSM) they were able to achieve significant improvements on the operational level; and these improve the performance of SMEs from all sides [16]. For example, they improved the time to value rate from 49 to 62% and the availability rate from 93.9 to 96%; in addition, the quality defect rate went from 4.33 to 3.6%, and inventory went from 15.3 to 4.5 days. In Morocco, Bajjou and Chafi opted for a quantitative approach using a questionnaire survey of private and public construction organisations, it was shown that the potential benefits derived from lean construction practices are: increased environmental performance, reduced time, costs and improved project quality [17-19]. In Thailand, the study by Choomlucksanaa et al. explores a real work-case study of the sheet metal stamping process [20]. The results obtained showed that the benefits of implementing lean are waste reduction and improved efficiency of production processes. After applying lean principles, non-value-added activities were reduced from 1086 to 281 activities, which is 66.53% of waste, and they reduced overtime cost by 1764 dollars per year, and the latter was considered as another benefit of lean implementation. AlManei et al. evaluated the frameworks of lean implementation in SMEs, and they showed that lean implementation could bring many benefits, such as waste reduction, production cost reduction, culture change, and improvement of operational efficiency and customer satisfaction [14].

In Switzerland, Christophe Rousseau production manager and head of the central sterilisation department in a university hospital and author of the book "Lean manufacturing: The secrets of your company's success" said that after implementing lean manufacturing, he reduced production waste which led to savings of CHF 6 million for the company over four years [21].

Table 1. Lean manufacturing benefits.

No.	Benefits of lean manufacturing	Country	Ref.
1	Waste elimination	North Africa	[15]
		Thailand	[20]
		United Kingdom	[14]
		Switzerland	[21]
2	Cost reduction	Morocco	[17]
		United Kingdom	[14]
		Switzerland	[21]
3	Improve product quality	North Africa	[16]
		Morocco	[17]
4	Acquisition of new markets	United Arab Emirates	[13]
		United Kingdom	[14]
5	Reduced delivery times	North Africa	[15]
6	Change culture	North Africa	[15]
		United Kingdom	[14]
7	Improving competitiveness	Thailand	[20]
8	Increased production volume	Thailand	[20]
		Morocco	[17]
9	Improved customer satisfaction	North Africa	[15]
		United Kingdom	[14]
10	Reduction of unnecessary inventory	Thailand	[20]
11	Improvement of the efficiency and performance of production units	Morocco	[17]
		Thailand	[20]
		United Kingdom	[14]

Lean Barriers of Implementation in the SMEs

Shrimali and Soni, in 2017 surveyed a representative sample of various Indian SMEs through a questionnaire with the main purpose of exploring the difficulties or barriers faced in implementing lean [22]. The results showed that among the most important barriers to the implementation of lean practices are resistance to change from middle management with a mean score of 4.26; lack of lean implementation team (mean = 3.26), lack of reward system (mean = 3.17), and little support from management (mean = 2.37). They also found that poor lean training, high cost, lack of skilled people influence the success of lean implementation in SMEs.

Similarly, Yadav et al. in 2019 used a case study approach to explore the barriers of lean implementation in SMEs. Three case studies within SMEs in India allowed the authors to validate different barriers to lean implementation; we found lack of management commitment, lack of leadership, organisational culture, lack of communication, lack of resources, resistance to change, lack of employee involvement, lack of training and skills, and lack of understanding of the benefits of lean and reinstatement of old methods [23]. After modelling the relationships between these barriers using structural modelling (ISM), it was found that lack of management commitment and leadership, lack of resources, and lack of communication are key OWLs in SMEs. To gain insight into the degree of relationships (driving power and dependency power), an MICMAC analysis was conducted. Using the MICMAC analysis, it was found that lack of training and skills has a high driving power as well as a high dependency power. The ISM model also suggests that management commitment, level of communication, and availability of resources affect training and skills, which in turn affect other barriers, namely reverting to old ways, employee involvement, organisational culture, and resistance to change. Similarly, lack of communication, resistance to change, and employee involvement are linking barriers, but with relatively less driving power. Reverting to old ways has a strong dependency, suggesting that other barriers may affect this while not affecting other barriers.

In 2018 in the healthcare industry, Sieckmann et al. analysed 27 articles to highlight the major obstacles faced by SMEs in the pharmaceutical industry [24]. The literature review showed that lack of commitment from top management, lack of knowledge, resistance to change, lack of training, poor application of lean tools, and lack of methodology and planning are the causes of implementation failure. In Poland, and to identify the problems during the implementation of the Lean concept in small and medium enterprises, Ulewicz and Kucęba developed a questionnaire survey that distributed it in the largest Lean conference in Central Europe to collect the maximum number of responses [25]. The results showed that SMEs face a major obstacle which is the lack of involvement of top management. On the other hand, the respondents reported that the lack of knowledge about lean techniques and tools is a major problem, and 20% of the responses explained it due to lack of training or inappropriate training.

In a developing country, such as the United Arab Emirates (UAE), these authors Alefari et al. aimed to assess the status of lean understanding, the barriers of lean, and the impact of different leadership styles on employee performance using a questionnaire sent to 150 UAE SMEs in the manufacturing sector and they received 87 completed questionnaires [13]. After analysis, it was found that the level of understanding of lean varies depending on the company's size. Large companies with more than 3 years in its lean journey, associated the lean concept with management philosophy and aspects of kaizen, while those with less than 3 years associated it with waste reduction and the set of tools for improving production, and only the responses of micro and medium enterprises with less than one year associated lean with the

reduction of labour. Respondents were also able to identify the root causes that lead to the failure of lean manufacturing implementation; these were lack of commitment and involvement from the top (i.e. top management) and bottom (i.e. employees), with a mean value of 4.3 being ranked first; then poor knowledge and understanding of lean tools and techniques; non-sharing of change and a need for high costs or investments. This is in line with several previous studies in the UK [26-27], in India [28], in Morocco [29-31].

In Norway and Belgium, Bakås et al. used the practical experiences of a set of SMEs in the European research project ERIP to identify barriers and obstacles to lean implementations [32]. They categorised the barriers into three dimensions differentiating SMEs from large companies, which are: resources, management, and organisation. In terms of resources, SMEs have limited and insufficient resources, which hinder their ability to hire qualified personnel and organise training activities; in terms of management, there is a lack of commitment from top management, lack of involvement of employees in improvement projects, lack of leadership, lack of attention to performance monitoring and resistance to change and finally in terms of organisation there is the lack of a functional organisation. Similarly, Kumar and Kumar in 2014opted for a quantitative approach using a questionnaire survey among 47 Indian companies, and they focused on the barriers that these SMEs face when they start the lean approach. They revealed a large list of barriers and that they grouped them into seven categories; management, resources, knowledge, conflicts, employees, financial issues and past experiences [33]. The results show that the top category was management with a mean value of 3.93 versus a mean value of 3.43; this category was identified as the biggest barrier and it includes lack of support from management and lack of long-term vision. Knowledge of lean came in second with an average value of 3.81 due to lack of training, lack of understanding of lean and lack of know-how. Another obstacle ranked third with a mean of 3.63 is conflicts; the authors cited that lean manufacturing can conflict with other systems present in the organisation, such as ERP [33]. Lack of financial resources and employee resistance to lean adoption were also recognised as barriers to lean manufacturing implementation.

AlManei et al. [14] echoed the research of Bakås et al. [32], indicating that the barriers identified, based on a structured literature review, are related to management, lack of necessary resources, employee resistance to change, and lack of knowledge about the lean philosophy and its various tools. In addition, in Malaysia, lean manufacturing has been widely implemented in small and medium-sized automotive manufacturing companies. The studies of Che Mamat et al. in 2015 showed that this implementation faced various challenges and obstacles which are mainly due to human factors such as lack of understanding and knowledge (tools, techniques, and implementation) of lean, employees' attitude (lack of commitment and involvement, resistance to changes), communication problems between different hierarchical levels, lack of commitment from top management, inadequate training, and many others [34]. So to ensure the success and survival of the lean implementation, it is necessary to take into account even the soft lean practices. To succeed, it is not enough to implement only the hard lean practices, which are the tools and techniques. Still, it is necessary to pay more attention to the soft lean practices, which refer to the soft/social aspects which are the human and relational elements - this is in line with several studies [35-38]. Based on the extensive review of literature, researchers [34] identified 11 elements of soft lean practices that considered it as soft practices, we find management commitment, human resource management, employee commitment, employee participation and empowerment, supplier management, customer orientation, training, teamwork, reward and recognition, communication and continuous improvement. Finally, they developed a conceptual framework that is essentially based on these 11 elements that are deemed necessary for the successful implementation of the lean production system.

On the other hand, in 2019 Chan et al. used questionnaires in Batu Pahat, Malaysia, to gather data regarding the main barriers leading to the failure of lean production system adoption [39]. The deductive approach showed that workers' attitude or resistance was the main barrier, and it was ranked first among ten items with a mean score of 4.82. In second place we find the lack of resources, after that there was the lack of formal training for workers, then the lack of support or commitment from the management, the lack of formal training for managers, the lack of consultants in the field, the lack of information sharing between managers and workers and lastly, there was the lack of co-operation and mutual trust between management and employees. In the same research direction, the study conducted by Belhadi et al. aimed to explore and analyse the implementation of lean manufacturing in SMEs in less developed countries through a survey of 84 SMEs in North Africa [16]. Lack of time and financial resources were ranked among the main obstacles influencing lean implementation, and then cultural issues were assessed as equally critical such as fear of new initiatives and resistance to change. On the other hand, companies in less developed countries also faced a lack of formal training for workers, a lack of understanding of lean, and employee empowerment.

Based on the literature review, it was shown that the implementation of lean faced various barriers that we have summarised in the following Table 2. This literature review presents the results of previous studies on lean production implementation failures in SMEs. According to the results, the main lean benefits drawn from the review are waste elimination and cost reduction. On the other hand, the root barriers identified that interrupt the adoption of lean are related to top management, resistance to change, financial resources and employee involvement.

In addition, this literature review showed that there are few studies on lean production failures in Moroccan SMEs. However, the obstacles revealed based on the literature review were estimated our benchmarks to determine if they are consistent and similar to the country of Morocco or not.

Table 2. Review of barriers of lean implementation in SMEs.

Review of barriers of lean implementation in SMEs	India				Germany	Poland	United Arab Emirates (UAE)		Morocco	Norway & Belgium	United Kingdom	Malaysia		North Africa
	[20]	[21]	[26]	[29]	[22]	[23]	[13]	[25]	[27]	[28]	[14]	[30]	[35]	[16]
Lack of real leadership		✓	✓	✓				✓	✓	✓		✓	✓	
Lack of commitment and support from top management	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Lack of financial resources	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Staff resistance to change	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Lack of training and knowledge on lean tools, techniques and implementation	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Lack of qualification of personnel	✓								✓	✓				
Lack of know-how, skill and expertise		✓	✓	✓	✓	✓			✓					
Lack of functional organisation		✓	✓						✓	✓				
Lack of methodology and formal procedures		✓	✓	✓	✓				✓				✓	
Lack of managerial education		✓	✓						✓		✓	✓		
Lack of state support									✓					
Lack of focus on performance monitoring					✓				✓	✓				
Lack of employee engagement and participation in the improvement project		✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓

RESEARCH METHODOLOGY

Based on the previous literature review and given that very few studies on this topic have been conducted in Morocco, this study is based on a questionnaire survey to have a current overview on the assessment of the level of lean manufacturing maturity within companies, and to examine the major barriers that hinder the successful implementation of lean manufacturing within companies. This research method is based on a representative sample of a population to generalise the results later, unlike if we study all the units or elements of the population, and there we will talk about the census, something that seems difficult to study all the existing companies in Morocco and that is why the use of surveys by questionnaire has become widespread nowadays [40-42]. This quantitative method of gathering information and collecting data to provide quantified and numerical results whose representativeness can be accurately assessed. Figure 1 illustrates the research methodology followed in this study.

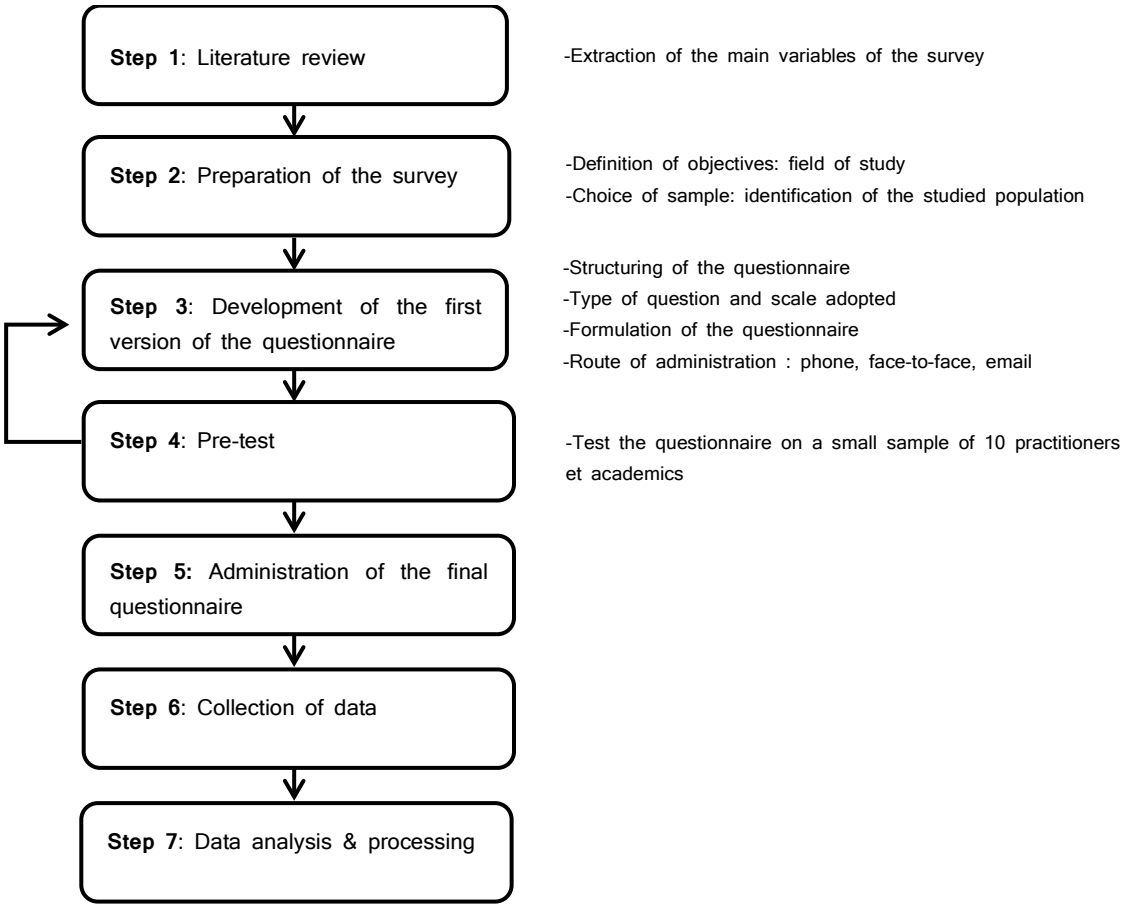


Figure 1. Research methodology followed in the study.

The literature review of previous research aimed to draw and extract the main variables that were estimated to be our reference points for our questionnaire survey. And based on this background research, we started to prepare our questionnaire by defining our field of study and identifying the study population. We designed the survey sample according to random sampling, and we drew it from the Moroccan chambers of commerce and industry by asking them to send us the lists of SMEs that we have in each region of the Moroccan kingdom to gather a large number of populations. In the third step, we were able to develop the first version of the questionnaire, we structured our questionnaire in parts and sub-parts, and we tried to write in a rigorous way a series of formalised questions intended to obtain information from respondents. These questions were of different types: multiple-choice questions, conditional questions, and even scaled questions. Different modes of dissemination of our questionnaire and collection of responses were used, namely: Phone calls, LinkedIn, emailing, drop off at the company, face to face, etc. Then, step 4 was to test the questionnaire on a small sample of 10 experts composed of two academics, four lean manufacturing and continuous improvement managers with more than five years of professional experience and certified lean six sigma, two process engineers and two quality engineers certified lean six sigma black belt; to check the clarity, readability, to see the errors of form and substance, to control the order of the questions and their understanding. And after correcting their remarks and suggestions, we designed our final questionnaire.

Questionnaire Design

The questionnaire is mainly composed of three parts:

i. The first part includes the main information about the company surveyed (sector of activity, size of the company, geographical location, main customers, and number of years of existence), the profiles of the respondents (level of education, position held within the company, number of years of experience)
ii. The second part, 'the level of lean manufacturing maturity within companies', describes the perception and knowledge of the lean concept for each respondent, the duration of the implementation of lean, and what they expect from the implementation of this improvement approach.
iii. The third part aims to identify lean benefits and to evaluate the degree of influence of each barrier based on a five-point Likert scale (1= does not influence at all, 2= does not influence, 3= no opinion, 4= influences a little, 5= influences a lot).

Data Collection

To collect a larger population, reliable and valid responses, the simple random sampling method was used. This method provides a sample that is representative of the population because it gives each individual or statistical unit the same probability of being in the sample. In order to perform simple random sampling, it was necessary to have a good sampling frame and select a list of all the statistical units in the population. For this reason, we contacted the Chamber of Commerce, Industry and Services of several Moroccan regions, but unfortunately, we did not receive a complete (up-to-date) list of all the individuals in the population; we received a list of 965 companies of different sizes and in different fields of specialisation. After that, we excluded the companies of size (very small and large), and we eliminated all the invalid emails and others that are repetitive. Finally, we retained 120 companies that represent the size of our sample, after which we distributed 120 questionnaires to Moroccan SMEs.

In addition, and as mentioned above, several methods of dissemination and collection of responses were used: some were sent by email, others were sent through social networks such as Linkedin, others were dropped off directly at the company or through phone calls. On the other hand, to ensure the capture, collection, quality, and timeliness of the results, all the data in the questionnaire was collected using Google Forms. The survey began in April 2018 in Morocco. A total of 84 completed questionnaires were collected out of the 120 questionnaires sent, which has a response rate of 70%, which is acceptable in academic studies [17, 39-40]. Finally, and after data collection, 78 completed valid responses (6 responses were incomplete) were statistically analysed using Statistical Package for Social Sciences (SPSS V21.0).

Instrumentation/Reliability of Questionnaires

After the internal validity of our questionnaire, a test to verify the reliability and internal consistency of the scale used to measure the influence of difficulties on the success of the implementation of lean production was deemed necessary. Cronbach's alpha test (α), a statistical indicator sometimes referred to simply as a coefficient α, was used to check the homogeneity and the degree of interrelation between the items. Cronbach's alpha (α) was named by Lee Joseph Cronbach in 1951, and is defined as Eq. (1) follows [45-46]:

$$\alpha = \frac{k}{k-1} * [1 - \frac{\sum {\sigma_{yi}}^2}{{\sigma_x}^2}] \quad (1)$$

Where, k is the number of items, σ_x^2 is the variance of the total score, σ_{yi}^2 is the variance of item i. The value of the coefficient is between 0 and 1. From 0.7, the coefficient is considered "acceptable" and many authors admit that Cronbach's alpha is more interesting when it tends towards 1 [47-48], while below 0.7 would be questionable, poor.

Our scale is composed of 13 items, which were used to measure the degree of influence of difficulties. The analysis of the collected data by SPSS software reveals the value of Cronbach's alpha test for this survey of 0.949, which is a very good score which proves that the 5-point Likert scale is reliable at the 5% level of significance and that we have a high degree of consistency between the analysed items and therefore it is considered acceptable and can be used.

Approach to Data Analysis

Descriptive statistics

Among the objectives of this survey is to identify the difficulties influencing the success of lean implementation within SMEs. To rank and prioritise the level of influence of each of the 13 items in descending order, the calculation of the weighted average or mean score (MS) collected by the surveyed sample was used. The average score is defined by the following Eq. (2) [49]:

$$\text{M.S} = \frac{\sum_{i=1}^{5}(\boldsymbol{x_i}\, \boldsymbol{w_i})}{\sum_{i=1}^{5} w_i} \quad (2)$$

where, $\sum$ denotes the sum, *i* denotes the index of the response category, such that 1= does not influence at all, 2= does not influence, 3= no opinion, 4= influences a little, 5= influences a lot, $\boldsymbol{w_i}$ is the weight given to the ith response, $\boldsymbol{x_i}$ is the frequency of occurrence or the value of the *i*-th response in the population.

Factorial analysis

Principal component analysis (PCA) is a factorial analysis technique and a multivariate analysis method, i.e. we studied several variables at the same time to associate a large number of variables in a limited number of factors. For example, in our case, instead of having 13 variables, we synthesised two factors that would contain the maximum amount of information contained in the former variables (see the results section). It is important to remember that we cannot use PCA with any variable but only with quantitative variables; for qualitative variables we can use the multiple correspondence analysis (MCA). To illustrate the PCA analysis process, we will use the stepwise procedure of Hair et al. [50]:

i. Preparation of the analysis:
   - Number of variables: We perform our analysis on 13 variables.
   - Type of variables: Since the responses are based on a Likert scale, the data are continuous.
   - Sample size: 78 valid and complete responses.

ii. Respect of the postulates: Before proceeding with the analysis itself and beginning the interpretation of the results, one question that arises is whether or not the PCA is feasible, whether or not what we have done is reliable. So that is why, before choosing the components, before saying that we are going to keep such numbers of factors and such numbers of components, we will first check the reliability of this analysis of this database.
   - Inter-item correlations: First of all, we must make sure that the variables are minimally correlated with each other. To do this, we look at the correlation matrix, which presents all the correlations between all the variables. On the other hand, one of the conditions of the principal component analysis is that the determinant of the correlation matrix is not equal to 0, and therefore, in this case, we can say that the reliability is verified and there are inter-item correlations.
   - Measurement of sampling adequacy (KMO): KMO is an index of the adequacy of the database that we subject to PCA analysis to determine whether that sample is adequate to conduct such analysis. It gives us an overall picture of the quality of inter-item correlations. It varies between 0 and 1 and is interpreted as follows:

     Less than 0.5: unacceptable
     0.5<KMO< 0.6: miserable
     0.6<KMO< 0.7: poor
     0.7<KMO< 0.8: good
     More than 0.8: excellent
   - Bartlett's sphericity test: This measure looks for whether the correlation matrix equals the unit variable, the latter means that the variables are pairwise independent, that there is no correlation between the variables. The result of Bartlett's sphericity test is significant if ($p<0.0005$) and in this case we can reject the null hypothesis that our data come from a population for which the matrix is an identity matrix [51].

iii. Choice of extraction method: We chose PCA, which is based on the specific variance and allows us to extract a minimum of factors that explain the largest possible part of the specific variance.

Company Demographics and Respondent Profile

In the first section of our questionnaire, we targeted several respondent profiles throughout the Moroccan kingdom to increase the response rate to the survey and to provide the greatest amount of information related to our topic. Figure 2 and 3 illustrate respectively the profiles of our respondents and the demographics of the companies surveyed. Note that 100% of our respondents are from small and medium-sized organisations.

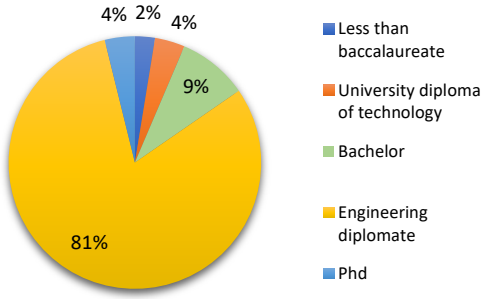
Respondents' profile

From Figure 2, we can see that most of the respondents have a high level of education (81% of the respondents have an engineering diplomate, 4% have a doctorate, 9% have a bachelor, 4% have a university diploma of technology and only 2% have less than a baccalaureate), and they have a good work experience (60% have between 1 and 5 years of work experience, 19% have more than 10 years, 18% are between 6 and 10 years old and only 3% have less than one year of work experience). Moreover, the respondents hold different positions within the company (21 respondents are quality managers, 13 are continuous improvement managers, 10 are process engineers, 9 are general managers, etc.).

Company demographics

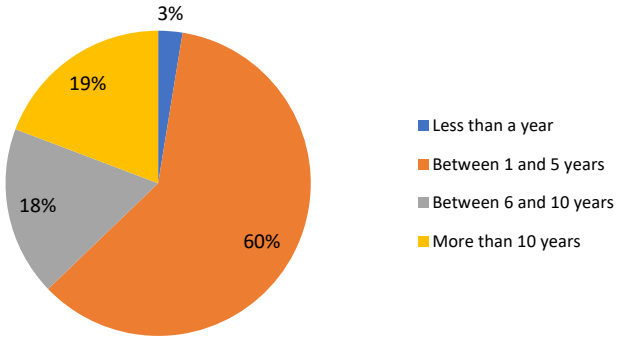
Similarly, Figure 3 presents the demographics of the companies. Geographically, the companies surveyed belonged to 6 regions of the Moroccan kingdom (40% of the SMEs surveyed are located in the Casablanca-Settat region, 24% are located in the Tangier-Tetouan-Al Hoceima region, 21% are in the Fez-Meknes region, 10% are in the region of Rabat-Sale-Kenitra, 4% are in the region of Souss-Massa and 1% are in the region of Beni mellal- Khenifra), and we note that 39% of the companies surveyed exist in Morocco between 10 and 20 years. In addition, our sample includes different sectors of activity (23% of respondents work in the automotive industry, 22% work in the food industry, 5.1% work in the pharmaceutical industry, 5.1% work in textiles and clothing, 5.1% work in the aerospace industry, 4% work in electricity and electronics, 4% work in the field of construction and public works, 2.6% work in the steel industry, 2.6%

come from business services, and 2.6% others come from consulting firms and consultants. On the other hand, to know the main clients of the companies participating in the survey, we asked them to choose the appropriate answer(s) (Answer 1= Public sector, Answer 2= Semi-public sector, Answer 3= Private sector). Respondents could choose one, two, or all three answers at a time since it is a multiple-choice question that we analysed using SPSS. The table below shows a multiple-choice frequency table:



(a) education level

(b) position held within the company



(c) working experience

Figure 2. Profile of respondents.

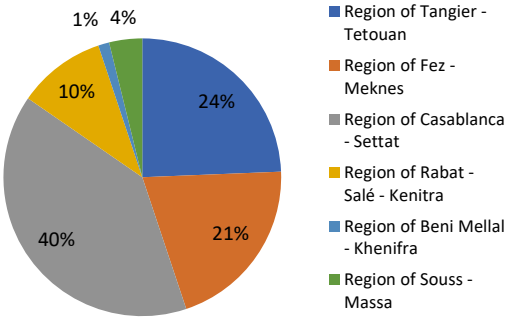
Table 3. $Main customers_frequencies[a].

Your main customers	Answers	
	N	Percentage of observations (%)
Public sector	15	19,2
Semi-public sector	15	19,2
Private sector	72	92,3
Total	102	130,8

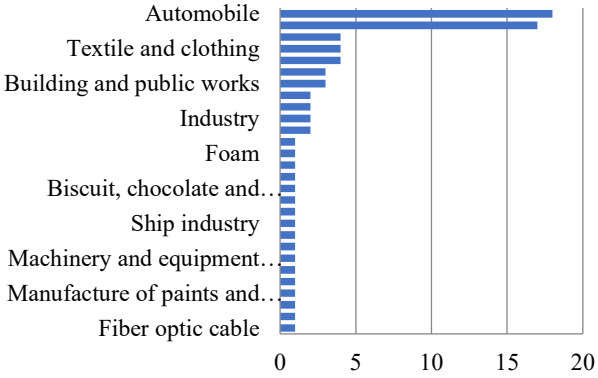
[a]Group of dichotomies tabulated at value 1.

NB: The $ sign in the title of Table 3 means that I have a grouped question, i.e. I have grouped all the items related to the same variable.

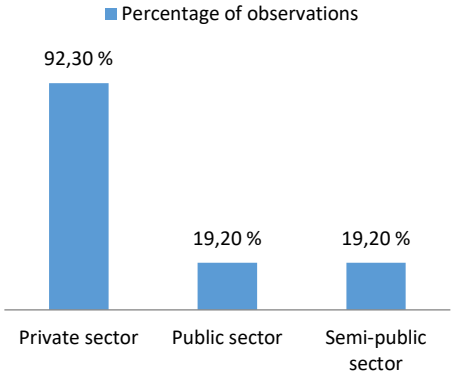
Interpretation: The total number of respondents is N=78. Note that the numbers in the first column of the table do not total 78, but 102, which is the total number of responses and is naturally greater than the number of respondents; since each respondent can give up to 3 responses. The second column of the above table shows the percentages of respondents (second column). Also, the sum of the percentages of respondents is greater than 100% because multiple responses are possible. This percentage can be interpreted by noting that each respondent has an average of 1,308 clients. Thus, 19.2% in the first row of the last column in Table 3 means that 19.2% of samples (i.e. 15/78×100) from the public sector has the main clients of the respondents and the same for the semi-public sector. In conclusion, we note that the sample includes 92.3% of the private sector that presents the main clients of the interviewed participants.



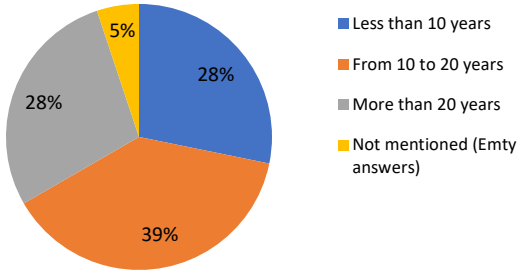
(a) distribution of SME geographic areas



(b) activity area



(c) the main customers



(d) number of years of existence

Figure 3. Company demographics.

RESEARCH RESULTS AND DISCUSSIONS: DATA ANALYSIS

Study of the Level of Lean Maturity Within Companies

To assess the level of lean maturity within companies, we asked respondents to answer the following questions:

i. Q1= What performance improvement approaches have your company adopted? (This is a multiple-choice question: Answer 1= TPM (Total Productive Maintenance), Answer 2= Lean manufacturing, Answer 3= Six sigma, Answer 4= ISO (9001, 14001...), Answer 5= None, Answer 6= Other (please specify).
ii. Q2= what is your level of application of these approaches?
iii. Q3= In your opinion, what is the level of need for lean manufacturing in your company?
iv. Q4= If your company has adopted the lean approach, how long have you been applying it?

Figure 4 presents the results concerning the questions asked. For the first question (What performance improvement approaches has your company adopted?), we analysed it in the same way as the main customers of the companies surveyed in the previous section, the table below presents the frequency table of the multiple-choice improvement approaches :

Table 4. $ Improvement_procedures frequencies[a]

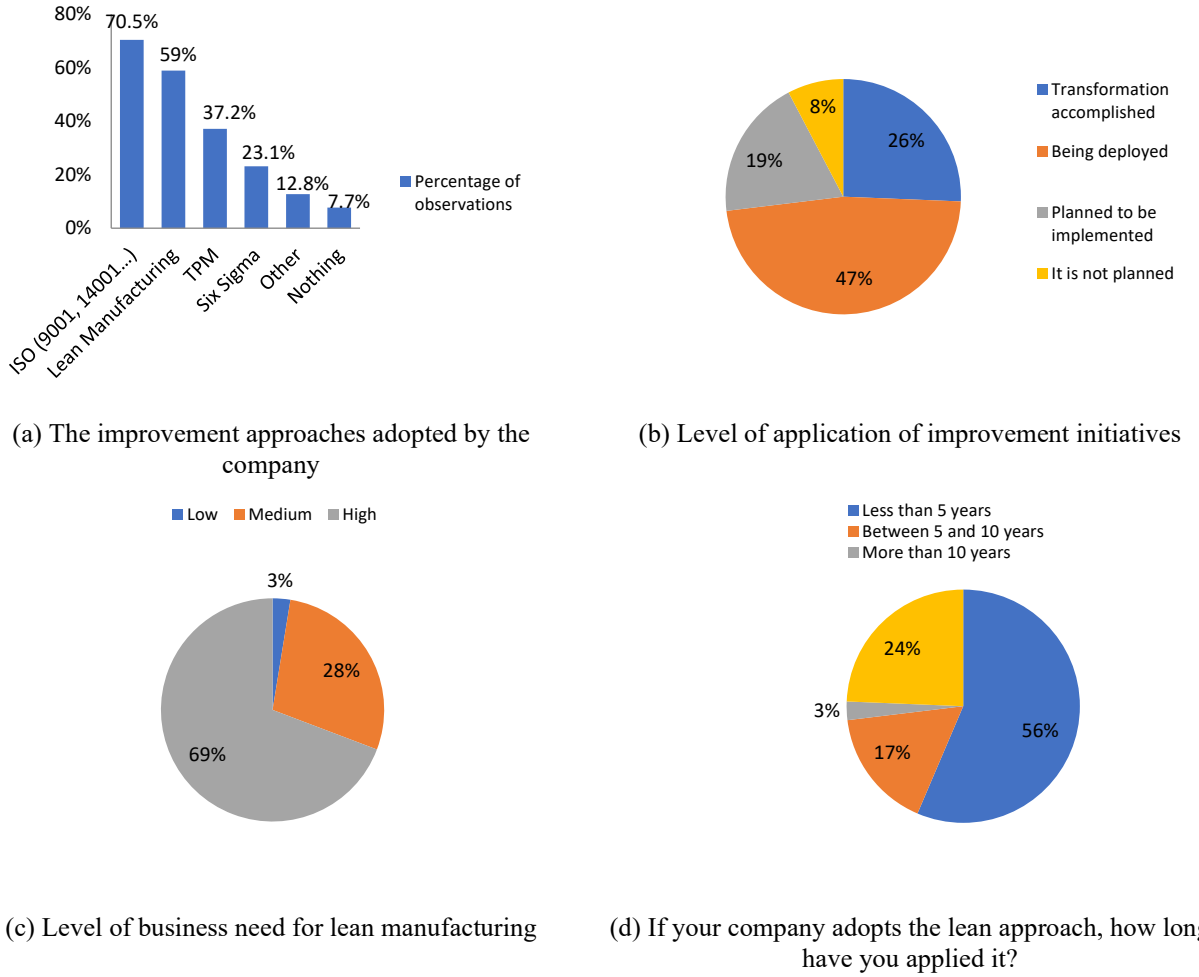
Performance improvement approaches adopted by the company	Answers	
	N	Percentage (%)
TPM	29	17,7
Lean Manufacturing	46	28,0
Six Sigma	18	11,0
ISO Certification (9001, 14001...)	55	33,5
None	6	3,7
Other to specify	10	6,1
Total	164	100,0

[a]Group of dichotomies tabulated at value 1.

We notice that our respondents adopt several approaches for performance improvement at the same time, in which 70.5% of the respondents mentioned that they adopt the ISO approach (9001, 14001), 59% adopt lean manufacturing, 37.2% adopt TPM, 23.1% adopt six sigma and 7.7% of the respondents do not adopt any improvement approach. In addition, 12.8% of respondents mention that they adopt other improvement approaches such as:

i. BSCI (Business Social Compliance Initiative) is an initiative that proposes companies to improve their working conditions by implementing an ethical supply chain.
ii. IATF 16949 is a standard that concerns the quality approach in the automotive industry.
iii. FMDS is the safety of the operation, which includes reliability, maintainability, availability and safety
iv. SPRINT is a specific approach to a company surveyed
v. QRQC (Quick Response Quality Control) / 8D is a quality approach
vi. 5S, SMED, Kanban, VSM, KPI (Key Performance Indicator): Lean manufacturing tools.

On the other hand, from Figure 3 we notice that almost half of the respondents (47%) are still in the process of deploying the performance improvement approaches, just 26% of the participants who have been able to accomplish their transformations, 19% have them planned to be implemented and 8% of the respondents have not yet planned the application of the improvement approaches. After we asked the people who participated in the survey, the level of need of the companies to lean manufacturing: 69% of the SMEs surveyed mentioned that the level of need to lean manufacturing is high, 28% mentioned that the level is medium, and only 3% quote that the level of need is low. And then, we would ask how long the companies have been applying the lean approach. Although 69% of the SMEs surveyed expressed a great need for lean manufacturing, we note that in Figure 3, more than half of the respondents (56%) have applied lean less than 5 years ago, which explains that they have just started experimenting with the lean concept in the last few years, 24% have not even tried to apply it yet, 17% of the respondents who have implemented lean have done so between 5 and 10 years ago, and only 3% who have applied it have done so for more than 10 years. We can therefore conclude that lean has just started to be implemented in Moroccan SMEs in the last 10 years. In addition, we would like to know if the companies surveyed received grants that helped them implement their improvement efforts. Figure 5 includes the responses to our questions.



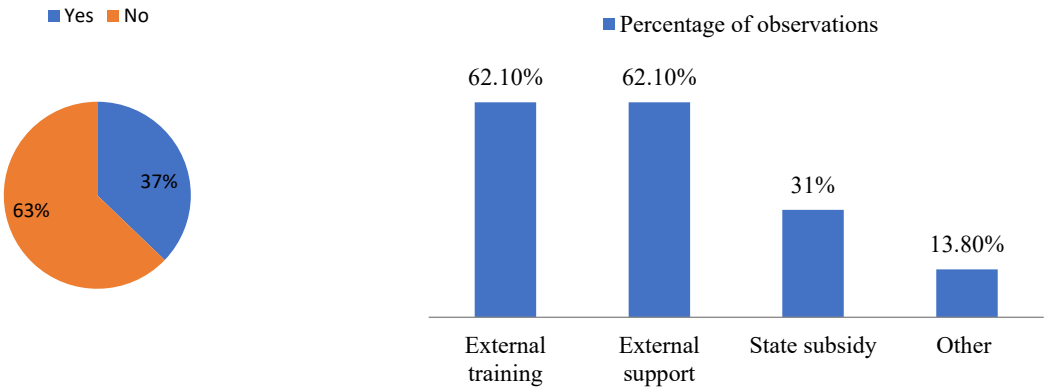
(a) The improvement approaches adopted by the company

(b) Level of application of improvement initiatives

(c) Level of business need for lean manufacturing

(d) If your company adopts the lean approach, how long have you applied it?

Figure 4. Lean implementation maturity.



(a) Have you received any subsidies?

(b) Type of subsidies

Figure 5. The different types of grants received.

From Figure 5(a), we notice that only 37% of the respondents received grants. The thing that pushed us to know is how it was implemented or, in other words, is it what type of subsidies, and here the respondents had to choose the type(s) of subsidies received, and if not mentioned, they had to specify the type of subsidies received (Answer 1= external training, Answer 2= external coaching, Answer 3= state subsidy, Answer 4 = Other (specify)). The table below shows the frequency table analysis of the multiple-choice types of support in SPSS.

Table 5. $Type_of_support frequencies[a].

Type_of_support	Answers		Percentage of observations (%)
	N	Percentage (%)	
External training	18	36,7	62,1
External coaching	18	36,7	62,1
State subsidy	9	18,4	31,0
Other	4	8,2	13,8
Total	49	100,0	169,0

[a]Group of dichotomies tabulated at value 1.

From the table, the total number of people who received grants is N=29 (29 presents 37% of the population). Figure 5(b) shows the percentage of observations in the table graphically. It can be seen that external training and external coaching have the same percentage of observations of the respondents, which is 62.1%, i.e., 62.1% of the respondents have received a grant. i.e. 62.1% of the respondents mentioned that external training was received as subsidies and the same for external coaching, 31% of the respondents mentioned that state subsidies were received to support the implementation of performance improvement approaches, and 13.8% of the respondents stated that they received other types of subsidies such as self-training, internal human resources, semi-state subsidy (ISITH) and INMAA which is *'the first Model Factory in Africa in the Middle East aimed at industrial companies wishing to implement an operational improvement program. INMAA is an innovative program that trains company managers to master and practice the principles of "Lean Manufacturing", a methodology recognised in the industrial world as an essential lever to achieve operational excellence'* in the name of the general manager Rachida Maliki of Inmaa Morocco [52].

Lean Benefits

As described earlier, identifying the benefits of lean was one of the objectives of our study. To this end, the eleven benefits revealed from our literature review were suggested in the questionnaire, then the respondents were asked to select the benefit(s) of lean production, and the results are presented in Table 6. To produce the number of respondents on the benefits of implementing lean manufacturing, we need to treat responses 1-11 as multiple response variables. Table 6 shows a multiple-choice frequency table, a view of the benefits of lean from the companies surveyed. The results in Table 6 show that ten factors out of eleven were selected by more than 50% of the respondents, which shows that Moroccan professionals are aware and convinced of the importance of lean manufacturing to achieve the objectives related mainly to waste elimination, cost reduction, quality improvement and so on. The numbers column indicates the frequency, occurrence, or the number of participants associated with each specific valid value of the selected variable. From the table, 64 people answered waste disposal as a benefit "choice 1", 61 people answered cost reduction "choice 2" for a total of 497 valid observations, the 497 presents the total number of responses which is naturally higher than the number of respondents N=78; since each respondent can give up to 11 responses. The percentage column gives the proportion of people for each possible value. Those who chose waste disposal "choice 1" represent 82.1% of the sample (i.e. 64/78 *100), those who chose cost reduction "choice 2" represent 78.2% of the sample. Figure 6 shows the ranking of benefits by percentages. As expected, the top five benefits that Moroccan companies expect from implementing lean manufacturing are 'eliminating waste 82.1%; reducing costs 78.2%; improving efficiency and performance of production

units 70.5%; changing culture 56.4% and increasing production volume 56.4%'. This is consistent with our literature review.

Table 6. $Lean_benefits_ frequencies[a]

What do you expect from the lean manufacturing implementation:	Answers N	Percentage of observations (%)
Choice 1: Waste elimination	64	82,1
Choice 2: Cost reduction	61	78,2
Choice 3: Improved product quality	41	52,6
Choice 4: Acquisition of new markets	22	28,2
Choice 5: Reduced delivery times	41	52,6
Choice 6: Change culture	44	56,4
Choice 7: Improving competitiveness	39	50,0
Choice 8: Increased production volume	44	56,4
Choice 9: Improved customer satisfaction	43	55,1
Choice 10: Reduction of unnecessary inventory	43	55,1
Choice 11: Improvement of the efficiency and performance of production units	55	70,5

[a]Group of dichotomies tabulated at value 1

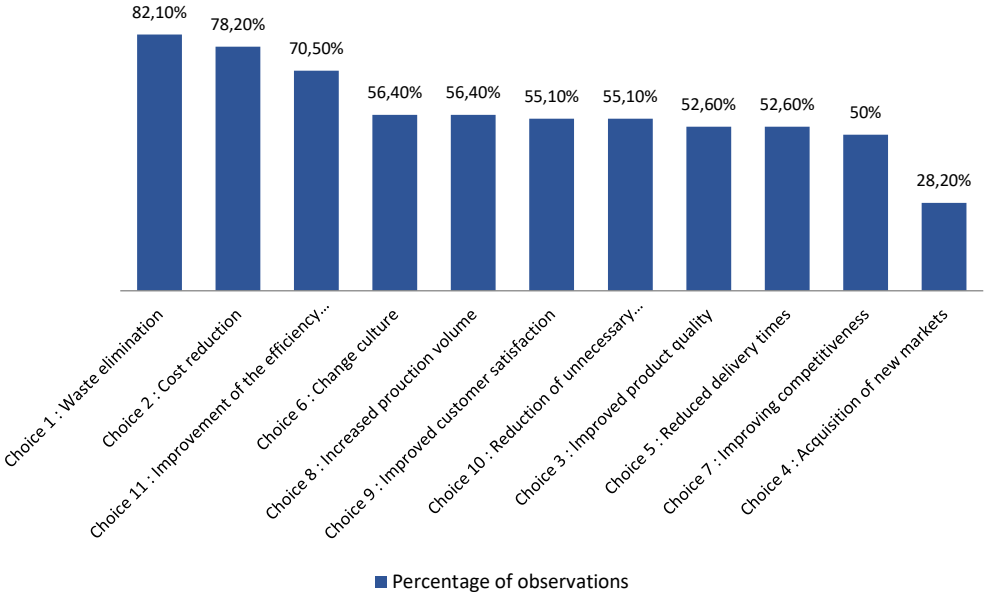


Figure 6. Lean benefits.

Lean Barriers

Once the internal consistency of the questionnaire has been validated, we can proceed to the statistical analysis. Next, we analysed the data received through the individual interviews and the answers of the Google form concerning the difficulties encountered by Moroccan SMEs during the implementation of Lean. In parallel to our questionnaire survey, we conducted semi-structured interviews in order to get a deeper understanding of the causes of failure of lean manufacturing implementation in SMEs, to obtain a list of difficulties encountered that we may not have cited in our Likert scale and to confirm the summary revealed from our literature review, and it was also decided to include an open-ended question in our questionnaire by asking respondents to tell us what difficulties companies may encounter when implementing lean manufacturing. We consulted and interviewed a group of lean experts, including 13 continuous improvement managers, 9 general managers, 21 quality managers and 2 lean manufacturing managers. The following Table 7 presents the analysis of the results of the testimonies of the respondents occupying different positions in SMEs in different sectors of activity.

These interviews confirm and validate the results of previous research; it seems that the difficulties encountered by the people participating in the survey in the six regions of the Moroccan kingdom are very similar to the 13 items extracted from the literature in different countries of the world (Malaysia [34], India [28], Poland [25], North Africa [15], and United Arab Emirates [13])

Table 7. Difficulties received through individual interviews and Google form responses.

People interviewed	Difficulties encountered	Sector of activity
2 lean manufacturing project managers	Lack of staff commitment, financial constraints, staff rigidity to change, lack of management involvement	Automotive, agri-food
3 specialised technicians	Lack of knowledge of lean culture, lack of team spirit	Pharmaceutical, automotive, food industry
9 general managers	Budget (financial constraints), lack of skills, lack of analysis data (measurable indicators, historical data, etc.), resistance to change and sustainability of achievements over time	Food processing, textiles/confections, aeronautics and automotive industry, construction, consulting, machinery and equipment manufacturing.
1 production director	Abandonment or stopping in the middle of the road	Automotive industry
2 Team leaders	No qualification of workers	Construction, food industry
1 Technical Director	Lack of staff commitment and resistance to change	Plastics
13 Continuous Improvement Managers	- Resistance to change is considered one of the major difficulties in industries afraid of downsizing. A continuous improvement manager stated that there are stubborn people who resist change. - Lack of commitment and involvement of management and managers, there must be involvement of everyone from top management to the operator, and management must set the example and paradigm, to win the change of culture, mindset, working methods and employee commitment, management must apply itself what it requires from others. - Lack of task communication and stress resistance - Lack of access to training, skills and experience - Cost of the project (financial constraints) - Lack of awareness of the benefits of the approach, lack of identification of waste and rigorous application	Electronics/Electricity, food industry, automotive, MMI (Mechanical and Metal Industry), aerospace, pharmaceutical, glass industry, waste management
21 Quality managers	- Resistance to change by employees and by some managers is the major problem and causes the unsuitability of the lean manufacturing approach - Lack of commitment and involvement of the different staff members, especially directors and managers (major difficulty) + time constraints + external constraints (related to customers and suppliers), - Lack of training, - Question of investment, - Internal personal conflicts - Lean manufacturing is not yet recognised, it is a question of unawareness, collaboration of employees, state of mind and behavior of the staff	Automotive, aeronautics, shipbuilding, food industry, pharmaceuticals, paint and varnish manufacturing, steel industry, textile / confection, construction, fish canning industry
3 Production Managers	Lack of management commitment, general company culture	Automotive, pharmaceutical, electronics / electrical
1 Director of Operations	lack of investment, culture	Business Services
1 Head of Support Department	- The fact that operational staff do not take the processes and steps of Lean Manufacturing seriously (absence of a real maestro or leader) - Lack of commitment from management	Steel industry
10 Process engineer	- The difficulties in my experience exist at the beginning of the implementation, since we have to document all the processes and stabilise them before moving to the implementation of JIT, TMP. - On the other hand, the top management is more focused on customer satisfaction than on internal process improvement, the implementation proposal must be in the right time'. - Lack of real leadership, - Lack of training and knowledge of lean tools and lack of organisation, - Resistance to change, - Lack of commitment, staff and budget, - Non-compliance with instructions by the staff, first of all, it is necessary to explain the usefulness of Lean to the staff so that they are integrated into the project, 'according to my little experience, we find it difficult to involve all the people, the awareness of the employees'	Automotive, business services, railways, agri-food, textile/confection
1 maintenance engineer	Lack of staff involvement	MMI (Mechanical and metallurgical industry)
2 Supply managers	Lack of qualified people to train operators, lack of collaboration between departments	Food industry, Biscuit, chocolate and confectionery industry

Descriptive Analysis

Our respondents were asked to evaluate the degree of influence of the previously revealed difficulties on the success of the lean manufacturing implementation based on the five-point Likert scale (1= does not influence at all, 2= does not influence, 3= no opinion, 4= influences a little, 5= influences a lot). To statistically represent and describe the data collected from the population or the sample under study, we used descriptive statistics. The latter is an important component and an essential step in the processing and analysis of data. The output produced by SPSS is presented in table 10, which presents the descriptive statistics of our 13 items.

Table 8. Mean Item Score (MIS) analysis of the causes of lean manufacturing implementation failure in the entire survey sample (Cronbach's Alpha = 0.949).

Items	N	Minimum	Maximum	Average	Standard deviation
Item1: Lack of real leadership	78	1	5	4,55	1,028
Item2: Lack of commitment and support from top management	78	1	5	4,45	1,158
Item3: Lack of financial resources	78	1	5	3,79	1,188
Item4: Staff resistance to change	78	1	5	4,27	1,053
Item5: Lack of training and knowledge on lean tools, techniques and implementation	78	1	5	4,24	1,047
Item6: Lack of qualification of personnel	78	1	5	3,86	1,125
Item7: Lack of know-how, skill and expertise	78	1	5	4,04	1,050
Item8: Lack of functional organization	78	1	5	3,96	1,145
Item9: Lack of methodology and formal procedure	78	1	5	3,97	1,151
Item10: Lack of managerial education	78	1	5	3,83	1,242
Item11: Lack of state support	78	1	5	2,85	1,280
Item12: Lack of focus on performance monitoring	78	1	5	3,85	1,349
Item13: Lack of employee engagement and participation in the improvement project	78	1	5	4,24	1,164
N valide (listwise)	78	N valide (listwise)	78	N valide (listwise)	78

The above table allowed us to summarise the collected data set according to a few parameters (Position parameters: min, max, mean; and dispersion parameter, the standard deviation), which allow us to make comparisons or predictions. The five-point Likert scale is considered an interval scale [53 – 55]. The mean is highly significant, and the results would be interpreted according to 5 intervals and presented in Figure 7:

i. Interval1: [1 to 1.8] means: does not influence at all
ii. Interval 2: [1.81 to 2.60] means: does not influence
iii. Range 3: [2.61 to 3.40] means: neutral, no opinion
iv. Range 4: [3.41 to 4.20] means: little influence
v. Range 5: [4.21 to 5] means: high influence

As illustrated in Figure 7, we notice that our 13 items have been classified into three categories of intervals. Items 1, 2, 4, 5, and 13 belong to the same interval (green) which is interval 5 and have an average between 4.21 and 5; this means that the majority of respondents evaluated that the absence of real leadership, the lack of commitment and support from top management, the resistance of staff to change, The lack of training and knowledge of lean tools and the lack of employee commitment and participation in improvement projects had a significant influence on the success of the lean implementation and were perceived as the main critical obstacles that had a major influence and role in slowing down or even failing to implement lean successfully. In addition, items 3, 6, 7, 8, 9, 10, and 12 belong to interval 4 (orange) and have an average between 3.41 and 4.20, so we see that among the difficulties that have little influence on the success of the implementation of the LM, we find: lack of financial resources, lack of staff qualification, lack of know-how, skills and expertise, lack of functional organisation, lack of methodology and formal procedures, lack of managerial education, and lack of focus on performance monitoring. Finally, the majority of respondents were neutral on whether or not the lack of state support influences the success of lean implementation in Moroccan companies, with an average of 2.85.

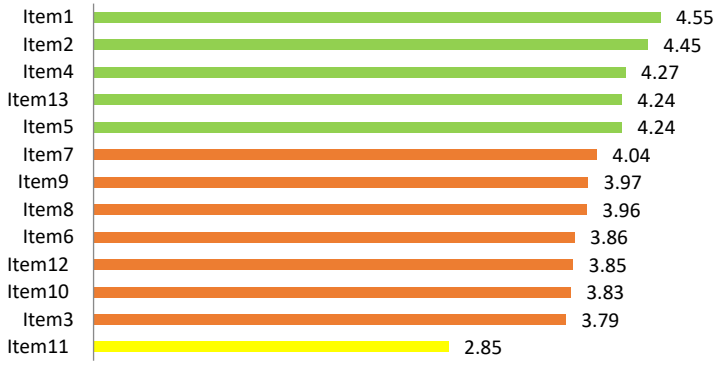


Figure 7. Mean score of items.

Spearman Correlation Test

Appendix A reports the normality test results for the collected data. The value of significance for the evaluated items for both tests (Shapiro-Wilk and Kolmogorov-Smirnov) was 0.000, which is less than the required normality criterion of 0.05. Accordingly, the gathered data could not be assessed using parametric statistical techniques that require the normality assumption since they were non-parametric in nature. Thus, the Spearman inter-correlation test, a non-parametric test used to study the level of inter-correlation between the thirteen items.

A Spearman rho inter-correlation matrix was generated by using SPSS software. In Table 9, Cells in gray highlight reflect moderate correlation (0.3<Spearman's correlation coefficient<=0.5) and cells in black highlight reflect high correlation (Spearman's correlation coefficient >0.5) [56]. The majority of the correlations were significant at the 0.01 level (two-tailed), 99% confidence level and 0.05 level (two-tailed), 95% confidence level, as shown in Table 7. Therefore, the whole data could be used for factor analysis.

Table 9. Spearman's rho inter-correlation matrix.

	Item1	Item2	Item3	Item4	Item5	Item6	Item7	Item8	Item9	Item10	Item11	Item12	Item13
Item1	1.000												
Item2	0.577**	1.000											
Item3	0.310**	0.299**	1.000										
Item4	0.476**	0.415**	0.310**	1.000									
Item5	0.529**	0.389**	0.159	0.300**	1.000								
Item6	0.436**	0.288*	0.377**	0.430**	0.483**	1.000							
Item7	0.600**	0.424**	0.305**	0.459**	0.455**	0.654**	1.000						
Item8	0.495**	0.397**	0.169	0.217*	0.426**	0.452**	0.550**	1.000					
Item9	0.491**	0.420**	0.183	0.409**	0.559**	0.472**	0.616**	0.644**	1.000				
Item10	0.624**	0.465**	0.245*	0.358**	0.365**	0.487**	0.619**	0.655**	0.625**	1.000			
Item11	0.229**	0.252*	0.422**	0.242*	0.264*	0.376**	0.376**	0.206*	0.421**	0.381**	1.000		
Item12	0.464**	0.387**	0.386**	0.490**	0.354**	0.446**	0.464**	0.429**	0.627**	0.444**	0.447**	1.000	
Item13	0.476**	0.501**	0.285**	0.538**	0.503**	0.424**	0.502**	0.534**	0.638**	0.421**	0.364**	0.710**	1.000

Factorial Analysis

In this section, we will show the results of principal component analysis (PCA), which corresponds to our database. The purpose of the PCA is to reduce to condense, reduce, compress, factorise the thirteen factors and, hence, generate a reduced number of latent factors. These new variables would then be combinations of the old variables. Table 10 presents the measured Kaiser-Meyer-Olkin (KMO) index, which reveals an overall view on the quality of correlation between the variables. This measure varies between 0 and 1, i.e. a value very close to 0 means that there is no correlation between the variables and that our PCA is not significant, and a value very close to 1 means that there is a very high correlation between the items and that our PCA is applicable and can produce reliable results. The KMO sampling accuracy measure gives a value of 0.901, which is very close to 1, which proves that our PCA is applicable.

Furthermore, the Bartlett test criterion was used to verify H_0 hypothesis. This hypothesis proposes that the correlation matrix between the variables is an identity matrix, i.e. that there are 1's on the diagonal and outside the diagonal, all values are zero, i.e. there are no correlations between the items. Thus, as shown in Table 10, the significance of Bartlett

is about 0.000 which is less than 0.005 (p-value <0.05), therefore, H_0 hypothesis is rejected. This test, therefore, allowed us to verify that our correlation matrix is far from being an identity matrix.

Table 10. Results of KMO and Bartlett's Tests.

Parameter	Value
Kaiser-Meyer-Olkin measure of sampling adequacy	0.901
Bartlett's test of sphericity	
Approximate chi-square	886.150
Df	78
Sig	0.000

In conclusion, these two criteria have enabled the validation of PCA to analyse all considered variables. Therefore, we can now proceed to the selection of the number of latent factors. Table 11 shows the total explained variance representing the amount of information retained in each component. Since we have 13 variables, there will automatically be 13 components, but the objective of our analysis is to reduce the number of variables while keeping the maximum amount of information revealed by our database. The first two components have a total eigenvalue greater than 1 and therefore, according to the criterion of eigenvalues, it is necessary to keep the components that have an eigenvalue greater than or equal to 1. Therefore, we will keep the first two components that provide 71.402% of the information. In other words, the first two components or latent variables alone represent approximately 72% of the total amount of information provided by the initial database.

Another criterion that can be used to determine the number of components to be kept for further analysis is the graph of Cattell presented in Figure 8. This rule consists in maintaining the number of factors located before the inflection point of the graph. Finally, components one and two should be retained since after component 2, there is an abrupt break in the curve after component 2.

Table 11. Total variance explained.

Component number	Initial eigenvalues			Sum of squares exctraction of the selected factors		
	Total	% variance	Of cumulative (%)	Total	% variance	Of cumulative (%)
1	8,274	63,648	63,648	8,274	63,648	63,648
2	1,008	7,754	71,402	1,008	7,754	71,402
3	,826	6,353	77,755			
4	,633	4,866	82,621			
5	,492	3,781	86,402			
6	,410	3,152	89,554			
7	,325	2,501	92,055			
8	,244	1,880	93,935			
9	,227	1,747	95,682			
10	,221	1,698	97,380			
11	,155	1,193	98,573			
12	,115	,887	99,460			
13	,070	,540	100,000			

Extraction method: Principal component analysis

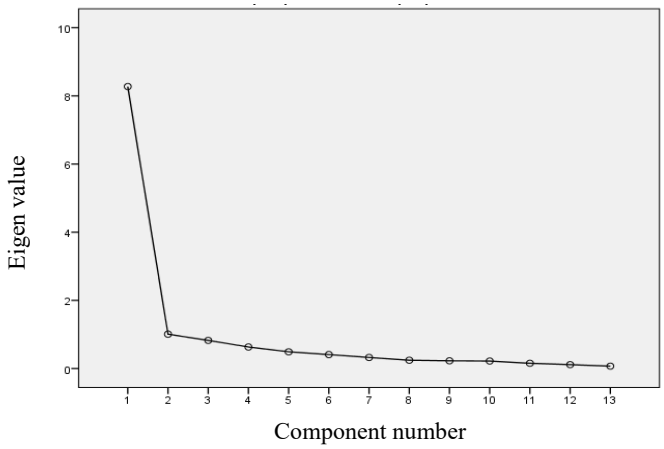


Figure 8. Eigenvalue graph.

Table 12 displays the matrix of components after Varimax rotation. The factor extractions were only considered if they were greater than 0.500. In our case, the whole items have extractions greater than 0.500; hence, there no item that

should be ignored. Each component may be named and analysed by combining the meanings of the variables with the highest extractions.

Table 12. Matrix of components after varimax rotation.

Items	Clusters	Factor loading
	Cluster 1: Poor management	
Item1	Lack of real leadership	0.876
Item2	Lack of commitment and support from top management	0.828
Item8	Lack of functional organisation	0.816
Item10	Lack of managerial education	0.804
Item7	Lack of know-how, skill and expertise	0.795
Item5	Lack of training and knowledge on lean tools, techniques and implementation	0.759
Item4	Staff resistance to change	0.695
Item13	Lack of employee engagement and participation in the improvement project	0.675
	Cluster 2: Lack of financial resources, monitoring, and skilled labors	
Item11	Lack of state support	0.835
Item 12	Lack of focus on performance monitoring	0.702
Item3	Lack of financial resources	0.681
Item6	Lack of qualification of personnel	0.567

Rotation method : Varimax with Kaiser normalisation.

Figure 9 displays the projection of the components on the factorial plane after rotation. The positive correlations that appear in this projection on the two main axes reflect the synergy between all the items.

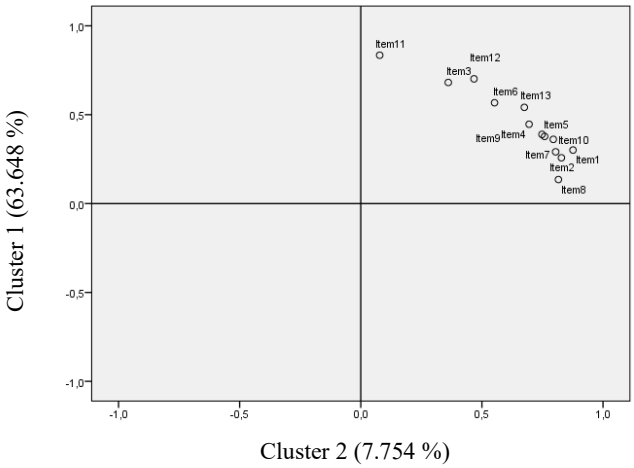


Figure 9. Component diagram in space after rotation.

In this projection, the first main axis is explained essentially by managerial aspects such as lack of real leadership, lack of commitment and support from top management, lack of functional organisation, and lack of managerial education. Those factors are due to the lack of effective management in manufacturing and non-manufacturing companies in Morocco. In this case, several strategies can be proposed to overcome this challenge, including (1) recruiting an experienced lean management consultant to help top management in launching the lean project, (2) organise training sessions for managers, especially those related to leadership, cross-functional team management, collaborative planning, and risk management, (3) employees involvement is a key factor of lean deployment success; hence, it is recommended to motivate their participation in the improvement process through training on lean production techniques and tools, contribution in waste reduction and proposal of solutions to root causes of recurrent problems, (4) implementing a reward program and improving work conditions to encourage employees to minimise sources of waste and contribute to the continuous improvement of the company, as suggested by [17], could be a promising solution to avoid staff resistance. It is worth noting that this component, 'Cluster 1: Poor management' explains 63.6 % of the total variance, which urge Moroccan professionals and researchers to focus their efforts on overcoming this challenge.

The second component is strongly associated with the lack of government support, the lack of staff qualification, the lack of financial resources, and the lack of focus on performance monitoring. It recommended (1) that the state disseminates innovative programs such as "INMAA" across all medium and small enterprises in Morocco, which helps increase the qualification of employees and enhance their awareness of Lean Manufacturing techniques, (2) to be able to successfully manage financial resources efficient including the efficient cash flow management using the progress payments, (3) as well as the urgent need to manage companies based on the monitoring of KPI (Key Performance Indicator) such as, productivity indicators, quality indicators, competitiveness indicators, and so on. The component 'Cluster 2: Lack of financial resources, monitoring, and skilled labors' explains 7.75 % of the total variance

CONCLUSION

In conclusion, this research presents a literature review on the status of lean implementation in small and medium-sized enterprises that allowed us to assess the understanding and benefits of lean and to determine the main obstacles to successful implementation. We then want to study the degree of influence of the obstacles examined from previous studies on the success of lean implementation. To achieve this, a questionnaire survey was developed and distributed to SMEs covering the entire Moroccan national territory and operating in manufacturing sectors (automotive, pharmaceutical, food processing, textile/clothing, construction, etc.) and non-manufacturing sectors (services, consulting, etc.). The companies surveyed were drawn from a statistical directory managed by the Chamber of Commerce, Industry, and Services. The results collected from 78 SMEs in Morocco showed that "elimination of waste" is classified as the top benefit expected by Moroccan professionals through Lean Production application. In addition, the principal component analysis revealed that the two main factors that hinder Lean deployment are: poor management (with 63.648 % of the total variance) and lack of financial resources, monitoring, and skilled labour (with 7.754 % of the total variance). The current study will help practitioners identify the critical barriers and obstacles that should be overcome for a successful Lean Production implementation. It is recommended that further investigations be performed, including large companies, hence increasing the availability of data for future comparison between large and SMEs companies. Additionally, there is an urgent need to develop a roadmap of Lean deployment to help practising engineering managers achieve more benefits of lean and overcome the critical barriers.

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APPENDIX A

Table A.1. Normality tests of the collected data.

Items	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	ddl	Signification	Statistique	ddl	Signification
CWF1	0.451	78	0.000	0.497	78	0.000
CWF2	0.427	78	0.000	0.529	78	0.000
CWF3	0.376	78	0.000	0.746	78	0.000
CWF4	0.295	78	0.000	0.691	78	0.000
CWF5	0.280	78	0.000	0.702	78	0.000
CWF6	0.306	78	0.000	0.813	78	0.000
CWF7	0.306	78	0.000	0.776	78	0.000
CWF8	0.308	78	0.000	0.781	78	0.000
CWF9	0.265	78	0.000	0.801	78	0.000
CWF10	0.271	78	0.000	0.810	78	0.000
CWF11	0.182	78	0.000	0.903	78	0.000
CWF12	0.251	78	0.000	0.789	78	0.000
CWF13	0.332	78	0.000	0.680	78	0.000