

Evaluation of the Operational Performance in Implementing Lean Manufacturing and Six Sigma

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Abstract - The aim of this study is to determine the performance outcomes for industries practicing lean manufacturing and six sigma. Findings indicate that company size (SME and large companies) has no influence on operational performance outcomes. This study also found that lean manufacturing and six sigma practices support increases and improvements in company's performance. The results of this study specifically revealed that use six sigma in all departments supportive of improving quality; whereas companies that implemented lean manufacturing in all departments created a safe environment and improved employee involvement. Moreover, findings illustrate that the use of a belt system supported the improvement in quality, reduced costs and reduced variation. The implementation of lean and six sigma are important areas of study as there are few studies reported in the literature on implementing lean manufacturing and six sigma within French industries.

Résumé : L'objectif de cette étude est de déterminer les résultats en terme de performance des entreprises ayant mis en place des pratiques de lean manufacturing et six sigma. L'étude indique que la taille de l'entreprise n'a pas d'influence sur la performance opérationnelle. Cette étude montre aussi que de telles pratiques augmentent la performance des entreprises. Tout spécialement, les résultats révèlent que le déploiement de six sigma dans l'ensemble de l'entreprise améliore la qualité alors que le déploiement du lean manufacturing améliore la sécurité et l'implication des salariés. De plus, les résultats montrent que l'utilisation d'un système Belt a un impact positif sur la qualité, la réduction des coûts et le niveau de variabilité du système de production

Keywords - Lean manufacturing; Six Sigma; Evaluation of the operational performance; Tools and technique.

1. INTRODUCTION

Lean origins are linked to the Toyota production system, which was a manufacturer's principle, attributed to engineers from Japan. In adopting this principle, Toyota adopted a system in which the main management focus was the reduction of waste [Wilson, 2010]. Six Sigma origins in Motorola and is based on the identification and measurement of variances within a process [Breyfogle, 2003]. Six sigma is governed by a philosophical maintaining that the reduction of variation will aid in the resolution of problems in processes and business operations. Ultimately, statistical evaluations can lead to understanding of process problems and therefore allow managers to predict and prevent difficulties arising in the process [Projasek, 2003]. Companies that integrated lean and six sigma, did so, as a means of compensating for the limitations in each method and this technique is denoted to as lean six sigma [Amheiter and Maleyeff, 2005; Muthukumaran et al., 2013; George, 2003]. Lean and six sigma are promoted as techniques for change and quality improvement in organizations [Näslund, 2003].

The aim of this study was to find out which of the methodologies lean manufacturing, six sigma or a combination of lean manufacturing and Six sigma was implemented by French industries. The study sought to find out the impacts that were associated with the implementation of the methodology. This

study also identifies the status of lean manufacturing and six sigma implementation within French industries, such as tools and techniques, and range in the implementation of lean and six sigma and whether organizations employed a belt system or not. Empirical data was collected through a survey distributed among companies in France. The vital contribution of this paper is that it includes the statistical analysis of lean and six sigma practices, and their awareness of implementing lean and six sigma in French industry, to recognize the status of these methods and the potential benefits

This research is structure as follow, the first section contain literature review of lean and six sigma. The second section, contains the research methodology, including the sample collection and the normality test of the data. The third section, related to the impact on lean and six-sigma implementation, the situation of extend level of lean and six sigma practices are investigated with a discussion of the findings. Last section, concluding remarks as well as the future work.

2. LITERATURE REVIEW

Six sigma methodology is related to 3.4 defects per million opportunities (DPMO) with the intention that identifying and

eliminating the defects, the organization can significantly improve quality of production [Breyfogle, 2003]. Six sigma requires the use of several statistical tools that focuses on the reduction of process. Six-sigma methodologies are applied in an organization as a means of solving quality problems and designing new and improved processes. The framework for implementing six sigma is Define, Measure, Analysis, Improve and Control (DMAIC), DMAIC is the most commonly used framework for problem identification and resolution in six sigma. DMAIC structures a continuous process for improvement via directing a sharp focus on the detection, analysis and resolution of root causes of process failure [Breyfogle, 2003]. On the other hand, lean manufacturing is a method that focuses on reducing cost through the elimination of the seven types of waste in all aspects of the organization, such as motion, over production, wait time, transportation, over-processing, defects, and inventory excess [Wilson, 2010]. Lean manufacturing includes various tools and techniques supportive of the elimination of waste such as value stream map, 5S, total productive maintenance and Kaizen, kanban, etc [Wilson, 2010]. The essential steps in lean are identification of features that create value include identification of value stream sequence of activities, making the activities flow, letting customer pull the product or service through the process and making the process perfect [Nave, 2002]. The implementation of lean and six sigma can produce more efficient and effective outcomes if there was an emphasis on human beings or organizational culture as opposed to a single focus on training staff in techniques and tools [Dahlgard and Dahlgard-Park, 2006]. Lean and six sigma methodologies are ideal for cutting cost, improving innovation and efficiency with improved quality [George, 2003]. Combining lean and six sigma resulted in improvements in innovation in products, process reforms and a significant increase in revenue [Byrne et al., 2007]. There is also a growing trend toward combining both lean and sigma or combining components of those two methodologies. However, studies in the literature do not generally reveal details about the implementation of lean and six sigma in France [Leseure-Zajkowska, 2013]. This research will therefore focus on the implementation of lean and six sigma in French industries.

3. METHODOLOGY

The research instrument used in this research was an online survey. The objective of the data collection via a survey method was to identify the impact of an implemented lean manufacturing, and a combination of the two methodologies lean manufacturing and six sigma within French industries. A survey measuring the performance outcome of lean manufacturing and six sigma were distributed among various French industries. The survey was designed as a Likert-type scale as follows: one representing "strongly disagree"; two representing "disagree"; three representing "neutral"; four representing "agree"; and five representing "strongly agree". A higher score for benefit was 5, and therefore implied stronger agreement of the respondents, and a lower score for benefit was 1 implying stronger disagreement. The survey was prepared in two languages: French and English. Contact was initially made via email through which the link to the survey was sent to 173 enterprises operating in various industries throughout France. Twenty-seven emails were not successfully delivered either because email addresses were not valid or the

participants did not qualify for inclusion since they had not implemented either lean manufacturing or six sigma methodologies within their organizations. Prior to distributing the survey, a pilot study was conducted using two academics and two experts in lean manufacturing and six sigma in order to test the validity of the research design. Based on the academics and experts' feedbacks, one question was added and minor items were modified prior to distributing the survey. Cronbach's alpha coefficient was used to test the internal reliability for the performance outcome variables. Cronbach's alpha coefficient is a measure for testing the internal reliability consistency [Nunnally, 1978]. A total of 33 experts specializing in quality and excellence were answered the survey. Even though all variables were measured on an ordinal scale, we conducted a Kolmogorov-Smirnov test in order to verify the normality, finding that the variables were not normally distributed (Kolmogorov-Smirnov=0.030). Therefore a non-parametric test was used. A statistical analysis was conducted using a Mann-Whitney test, a Kruskal Wallis test, and a Spearman's rho. SPSS version 20 was used. A linear regression analysis was used to find out the impact of implementing lean and six sigma practices on operational performance. The results of Cronbach's alpha coefficient indicated a reliability coefficient at 0.902, and therefore the internal reliability consistency is satisfactory. The response rate was 19%.

4. RESEARCH FINDING AND ANALYSIS

4.1 PROFILES OF THE RESPONDENT ENTERPRISES

A majority of the companies were certified by various types of certification. In this regard, 23 out of the 33 companies representing 69.7% are ISO 9001 quality management systems certified; 14 out of the 33 companies or 42.4%, are ISO 14001 Environmental Management Standard certified, 7 out of the 33 companies or 18.2%, are OHSAS18001 Occupational Health and Safety Assessment certified, and 5 out the 33 companies or 15.1 % are ISO13485 International organization for standardization certified. Therefore, a majority of the companies participating in the study have quality management stander. A majority of the organizations, specifically, 63.6%, did not employ a classification of belt systems: 'champions', 'master black belts', 'black belts' and 'green belts'. Only 36.4 % of the participating organizations employ belts systems. Based on the European Commission's definition of SME (a company or business employing no more than 250 workers) and large companies or businesses (an organization that employs at least 250 workers), the sample used in this study consisted of 12 SMEs and 21 large companies.

Table 1. Profile the respondents

Type of industry	Frequency	Percent
Electronic Industry	10	30.3
Automotive Industry	7	21.2
Health Industry	4	12.1
Service	6	18.2
Transport	2	6.1
Other	4	12.1
Age of the companies		
Less than 5 years	1	3.0
Between 5 and 10 Years	4	12.1
Between 10 and 15 years	3	9.1
More than 15 Years	25	75.8
Method implemented		
Lean Manufacturing	20	60.6
Lean and six sigma	9	27.3
Don't chosen either lean or six sigma but companies practices various lean and six sigma practices	4	12.1
Number of years		
Less than 3 years	16	48.5
Between 3 and 6 years	9	27.3
Between 6 and 9 years	2	6.1
9 years and more	6	18.2
Size of companies		
SME	12	36.4
Large companies	21	63.6

Table 1 above presents the general profile of the companies participating in the survey. Nine companies representative of 27.3% had implemented lean manufacturing and six sigma. Twenty companies representing 60.6% of the participants had implemented lean manufacturing even though many of these companies had been implementing six sigma practices such as Design of experiment (DOE), DPMO, and DMAIC. Despite the fact that four companies or 12.1%, implemented many of the lean and six sigma practices, although they do not describe them as lean and six sigma methods with their organizations. (48.5%) of French organizations in our sample have implemented lean and six sigma or elements of one or other method for less than three years, (27.3%) had implemented the methodologies from between three and six years, (6.1%) from six to nine years, and (18.2%) for a period of nine years or more. So majorities of the sample have an experience of 3 or more years in the management of this kind of methods.

4.2 LEAN MANUFACTURING AND SIX SIGMA PRACTICES

In order to understand the situation of lean manufacturing and six sigma practices in French industries, The respondents were asked also to identify the extending level for lean and six sigma implementation within their organization using a five-point scale, choosing from 1= "not implemented to any department " to 5= "Implemented in all departments including supplier".

Table 2 illustrates the percentages of how French companies extended lean and six sigma. The results show that 36.4% of the French companies embraced lean in whole departments and 36.4% of the French companies extended lean to at least some departments. 12.1% of the participating French companies extended lean in few departments. Another 12.1% of the

participating French companies had not extended lean to any departments and one companies representing 3%, extended lean to all departments including the supplier. On the other hand, 72.7% of the companies, representing a majority, had not implemented six sigma to any department. Results indicated that 12.1% of the participating French companies extended six sigma in a few departments. Three companies representative of 9.1% of the participating French companies implemented six sigma in some departments. 6.1% of the companies extended six sigma to whole departments and no companies applied six sigma to whole departments including suppliers. It seems that French industry have more interested of implementing lean manufacturing than six sigma method.

Table 2. Extending lean and six sigma methods

Extending method	Lean	Six sigma
Not to any department	12.1%	72.7%
Few departments	12.1%	12.2%
Some departments	36.4%	9.1%
All departments	36.4%	6.1%
All departments including supplier	3%	0%

Table 3 shows the tools and technique that were relevant to the implementation of lean manufacturing and six sigma within the French organizations participating in this study. Lean manufacturing and six sigma practices were analyzed according to their implementation within their respective organizations. The purpose of the data collection and analysis was to identify how different companies practice these tools. Each item was measured using a five point Likert scale. Relative scales ranged from 1 = no implementation to 5 = wide implementation. A higher percentage for implementation demonstrates that lean manufacturing and six sigma techniques are used more extensively (Where these tools and techniques were implemented and used more commonly). On the other hand, a lower percentage indicates that lean manufacturing and six sigma tools are not used extensively. All of the tools and techniques of lean manufacturing and six sigma have been implemented at a variety of levels by the participant companies. PDCA and cause and effect diagram had a higher score and common use of these practices inferring that companies look for continuous improvement through continuous evaluation, problems and continuous redesigning of processes.

Table 3. Range Lean manufacturing and Six Sigma practices

Companies implemented lean manufacturing and six sigma		Companies implemented lean manufacturing		Companies using the tools but not referring as lean and six sigma methods	
<i>Practices</i>	<i>%</i>	<i>Practices</i>	<i>%</i>	<i>Practices</i>	<i>%</i>
Brainstorming	88.8	PDCA	80	PDCA	75
PDCA	82.2	Visual Control	77	5S	70
Cause and effect	80	Standardized Work	76	Cause and effect	65
Pareto chart	77.8	5S	74	Flow chart	60
VSM	77.8	Cause and effect	73	VOC	55
Kaizen team	75.6	Flow chart	70	Brainstorming	55
Visual Control	73.4	Pareto chart	70	Standardized Work	55
Standardized Work	73.4	Brainstorming	69	Control chart	50
5S	73.4	Check sheet	65	Pareto chart	50
VOC	71.2	VSM	63	Check sheet	50
Gemba	71.2	Gemba	61	Visual Control	50
DMAIC	68.8	Kaizen team	60	TPM	45
Flow chart	60	VOC	60	Kaizen team	45
Takt time	57.8	TPM	58	DPMO	40
Check sheet	53.4	Kanban	57	Kanban	40
Poka-yoke	53.4	Poka-yoke	55	Poka-yoke	40
TPM	53.4	SMED	55	SMED	40
Control chart	51.2	DPMO	52	Once piece flow	40
DPMO	48.8	Takt time	51	DOE	35
DOE	48.8	Control chart	50	Takt time	30
Kanban	48.8	Once piece flow	45	Regression analysis	25
SMED	48.8	Cellular layout	44	DMAIC	25
Once piece flow	48.8	DOE	42	VSM	25
Cellular layout	42.2	DMAIC	41	Gemba	25
Regression analysis	33.4	Regression analysis	29	Cellular layout	25
	N=9		N=20		N=4

Companies that implemented lean manufacturing and six sigma practices more extensively, either of the lean manufacturing or six sigma practices such as DMAIC, Design of experiment (DOE), regression analysis, VSM, GEMBA and kaizen, team take time, one piece flow, as opposed to other companies. These practices are indications that these companies use more statistical tools and are more aware of lean manufacturing and six sigma practices. Therefore, these companies were more frequently implementing lean and six sigma practices. This practices demonstrated that these companies were intent on achieving continuous improvement within their organizations. Where companies that implemented lean manufacturing, also use the tools and techniques of six sigma such as DMAIC, and design of experiment, but only slightly practiced these tools. On the other hand, the results show more extensive practicing with tools and techniques such as 5S, TPM and kanban, and cellular layout. But also it was observed that Kaizen and VSM were not be the

highest priority among companies that implanted lean compared to companies implemented lean and six sigma were found to be more matured of these practice. Other illustration explained by Ronald (2010) that lean tools could generate to use six-sigma project. For example if VSM discover complex problem without known the issue then six-sigma method might be the solution to resolve the problem (Ronald, 2010). Additionally, George (2003) states that both method complemented each other. Therefore it can be interpreted from the literature review and our results that implemented both methods contributed to be more conscious and knowledgeable on lean manufacturing and six sigma practices. While companies that have not reported implementing lean manufacturing or six sigma methods, have the lowest extensive practice involving lean six sigma practices within their respective organizations. This indicates that these lean six sigma practices were implemented, but not used usually or were not commonly used. Even though, the results do reveal some measure of

achievement in the improvement of company performance outcomes, as shown in the scores for performance outcomes in Table 4.

4.3 IMPACT OF LEAN MANUFACTURING AND SIX SIGMA IMPLEMENTATION

Descriptive statistics were used in analyzing and interpreting the survey results. Companies were categorized also into three groups

commensurate with their implementation methods as a means of analyzing the participants' operation performance outcome variables (See Table 4). In this regard, A-Companies implemented lean manufacturing and six sigma, B-Companies implemented lean Manufacturing, and C-Companies have not reported implementing lean or six sigma method, even though these companies has been implementing many of the lean manufacturing and six sigma practices

Comparing companies' performance that are linked to the implementation of the chosen methodology

Benefit	Companies implemented lean manufacturing and six sigma	Companies implemented lean manufacturing	Companies using the tools but not referring as and six sigma methods with their organization
	Mean	Mean	Mean
Increase profit	4.12	3.90	3.25
Improve quality	4.63	4.19	4.00
Reduces variation	4.25	3.95	3.75
Reduces cost	4.50	4.00	3.75
Improves productivity	4.13	4.38	3.50
Reduces Lead-time	4.13	4.33	3.50
Increases suggestions from the employees	3.50	3.90	2.75
Involves employees	3.63	4.00	2.75
Increase Customer satisfaction	3.50	4.10	3.75
Decreases Inventory	3.13	4.24	3.75
Reduce turnover rate	2.88	2.95	2.00
Creates safety environment	2.88	3.48	2.50

Observation reflected for the impact on the operational performance, it is clear that they gained various benefits of performing lean and six sigma, but the level of advantage varies among organizations. It suggest that French companies implementing lean manufacturing and six sigma achieved better mean performance levels than French companies that implemented only lean manufacturing and companies that implemented only lean and six sigma tools in terms of increased profit, improved quality, reduced variation and reduced cost. These average scores reveal that companies implementing lean and six sigma achieve greater benefits along several important variables indicative of efficiency and quality, relative to other companies choosing only to implement either lean manufacturing or utilize lean and six sigma alone. It can therefore be concluded that companies improve efficiency, quality and performance when using a combination of lean manufacturing and six sigma methodologies. While companies that implemented lean manufacturing achieved better performance such as improved productivity, reduced lead-time, increased customer satisfaction, improved employee involvement and suggestions and at the same time created a safer environment. These results are remarkable because the combination of lean and six sigma produced greater efficiency and effectiveness through improving process speed, reducing recycled time, added value among other improvements. Figure 1 demonstrates the percentage of the performance outcomes through the implementation of lean, six sigma.

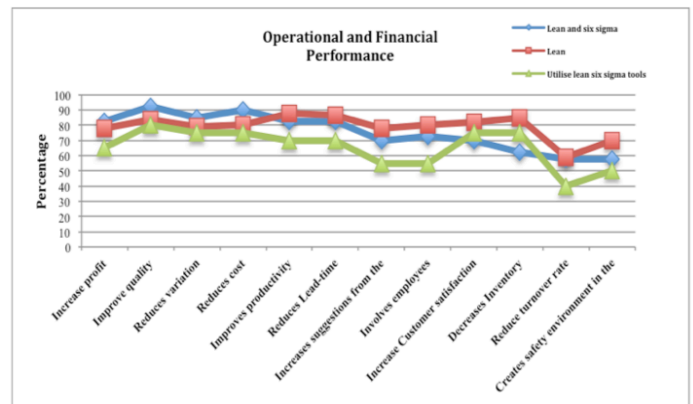


Figure 1. Performance Outcomes for Lean, Six Sigma.

Mann Whitney U test was conducted to identify whether or not there is a significant statistical difference between SME and large companies on operational performance. The results indicate ($P > 0.05$) no statistically significant difference between SME and large companies on all operational performance, such as improved quality, increased profit, improved productivity etc. All indications are that company size had no influence to operational performance outcomes. Therefore, in French industries, size is not an effective factor in the implementation of lean manufacturing and six sigma on financial and operational performance outcomes. In the other hand, the relationships between the various

ages of the organizations relating to companies performance were conducted with Kruskal Wallis test. The result indicate ($p > 0.05$) no significant difference between various age of the organizations and all twelve variable, additionally the Spearman's rho correlation resulted emphasis that the benefit has no influenced by age of the organization. This finding proposes that different ages of companies have a similar impact on operation performance.

4.3.1. Tools and technique

A linear regression analysis and Spearman rho correlation were used to find out the impact of all lean and Six Sigma practices implementation on operational performance. Findings were statistically significant (p -value= 0.00 and R square = 0.222). The results also showed significant correlation (p -value= 0.00, $R= 0.423^*$), meaning that lean and six sigma practice influenced the operational performance. Therefore it can be concluded that the more extensively a company implements these practices, the greater the performance outcomes.

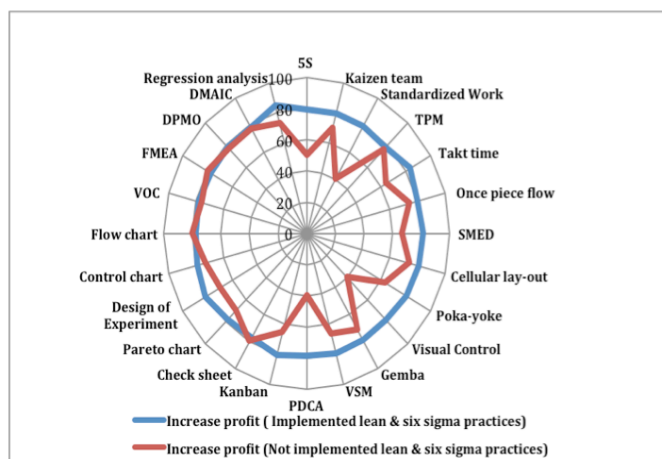


Figure 2. Comparison the effective of lean six sigma practices on increase profit.

Figure 2 shows the effectiveness of implementing lean manufacturing and six sigma practices for increasing profits. Specifically, illustrates a comparison between companies that implemented lean and six sigma, and companies that had not implemented. Companies implementing lean and six sigma practices supported to increase profit with each of the tools and techniques used in these methodologies such as Design of experiment, Kaizen team, VSM, Gemba, SMED, 5S etc, compared to the companies that did not utilize lean six sigma practices. Clearly, lean and six sigma practices demonstrate best practices for improving performance outcomes, it is the combined lean manufacturing and six sigma practices that will produce optimal results.

A review of literature indicates that large companies are more likely to implement lean and six sigma practices than SMEs are. In order to verify this claim, the Mann Whitney test is used in this study to determine whether there are any differences between SME and large companies in the level of implementation of lean six sigma practices at the level of significant 0.05. Based on the Table 5, some of these practices showed statistically significant differences between SME and large companies at significant level of 0.05. These lean six sigma practices include one piece flows, Gemba, DPMO, DMAIC and no differences were found between SME and large organizations in this study related to other

practices of lean and six sigma. Implicitly, large companies implement lean and six sigma practices on a wider scale than SMEs and use tools and techniques, especially six sigma methods such as DPMO and DMAIC that focus on the reduction of variation. DMAIC and DPMO are among the important fundamentals of implementing six sigma method. Being able to combine non-statistical and statistical tools and techniques in the implementation of the DMAIC model is among the factors necessary for the successful implementation of six sigma (Antony et al., 2005). For the most part, SMEs are hindered in the implementation of six sigma because they either lack awareness of six sigma or the resources necessary for implementing six sigma (Antony et al., 2005). It appears that SMEs within the French industry may lack the necessary resources in terms of finance, manpower, and skills. These constraints limit their ability to implement DMAIC and DPMO. SMEs are not using six sigma methods and have difficulty implementing six sigma methods most likely because they may not be aware of six sigma. On the other hand in order to improve process flows, lean tools and technique will be suitable. It shows that one piece flow and Gemba techniques appear to present SMEs with difficulties. In order to be a lean manufacturer it is required that the company adopts a way of thinking that focuses on making the product flow through value added processes via one piece flow, a “pull” system that reflects and is consistent with customer demands with the result that replenishment is consistent with what the next operation removes at short times (Wilson, 2010). One-piece flow that is underachieved will result in several issues such as, long manufacturing lead time, poor on-time delivery, large amounts of WIP etc. According (Doolen and Hacker, 2005) indicate that smaller companies have struggled involving with some lean practices, since small company have various customer and a schedule that changes all the time. Additionally Gemba technique one of lean technique is supporting to identify the entire process in the shop floor that helping to identify the issue and solving the problem (Rahani and al-Ashraf, 2012). It appears that SMEs encounter difficulties performing some of lean and six sigma practices.

Table 5. Level of implementation of LSS practices between SME and Large companies using Mann Whitney test

Lean six sigma practices	SME	Large companies	p value
Once piece flow	1.50	2.71	0.011*
Gemba	2.25	3.38	0.03*
Defects per million opportunities	1.75	3.00	0.024*
DMAIC	1.75	2.67	0.055*

Note. 2 tailed Significance level on Mann-Whitney test: * $P < 0.05$; ** $P < 0.01$

4.3.2 EXTENDING LEAN AND SIX SIGMA

It shows increasing of extending lean manufacturing and six sigma reflected to rise company operational performance such as improve quality, reduce variation, reduce cost, improve productivity, reduce lead time, increases suggestions from the employees, involves employees. On the other hand Implementing lean manufacturing to all department assistants more to decreases Inventory since lean contain various tools such as value stream mapping, 5s, TPM etc, that advantage to decrease inventory. Where six sigma that contain advance statically tools that

specifically apply it only when the issue are vague that help to diagnose the complex problem in improving decrease inventory [Snee, 2010]. Additionally, lean emphasis to attack the seven type of waste, one of these waste is reducing inventory. Therefore, implementing lean to all departments get surplus positive to decrease inventory. Also it was observed a surprising result that implementing six sigma to all department leads to decrease customer satisfaction compared to companies that not implemented six sigma to any departments. It may cause of the sample size was significantly smaller having only 2 companies that deploy six sigma in all department. However, The results indicating the mean scores of extending level for lean and six sigma within the organization and the impact on performance are presented in the Table 6.

Table 6. Comparable between the extending level for lean and six sigma

Impact performance	Extending level	Lean	six sigma
Increase profit	Not to any department	3.25	3.82
	All department	4.00	3.50
Improve quality	Not to any department	4.00	4.17
	All department	4.25	5.00
Reduces variation	Not to any department	3.75	3.87
	All department	3.92	4.50
Reduces cost	Not to any department	3.75	4.00
	All department	4.33	4.50
Improves productivity	Not to any department	3.50	4.30
	All department	4.50	4.50
Reduces Lead-time	Not to any department	3.50	4.30
	All department	4.42	4.50
Increases suggestions from the employees	Not to any department	2.75	3.74
	All department	3.92	3.50
Involves employees	Not to any department	2.75	3.83
	All department	4.08	4.00
Increase Customer satisfaction	Not to any department	3.75	4.13
	All department	4.00	3.50
Decreases Inventory	Not to any department	3.75	4.22
	All department	4.17	2.50
Reduce turnover rate	Not to any department	2.00	2.83
	All department	2.83	2.00
Creates safety environment	Not to any department	2.50	3.39
	All department	3.67	2.50

Mann Whitney U test was used for measuring differences between companies that had not implemented lean manufacturing and six sigma methods in any department and those that implemented lean manufacturing and six sigma methods in all departments on operational performance. As shown in Table 7, there are significant differences in improved quality between companies not implementing six sigma to any department and

those implementing six sigma in all departments. The differences were indicated in the range of a mean value from 4.17 to 5. While for lean manufacturing, there was a significantly higher differences in the creation of a safe environment and improved employee involvement for companies implementing lean manufacturing in all departments compared to companies not implementing lean in any department. The differences were in the range of a mean value of 2.50, and 2,75 to 3.67 and 4.08. An overall, integrate lean manufacturing and six sigma to whole departments are effective to increase company performance.

Table 7. Comparable impact in performance when extending the level of lean manufacturing and six sigma using Mann–Whitney test at 1% and 5% significance levels

Impact performance	Six sigma		Lean Manufacturing	
	Z	P-Value	Z	P-Value
Increase profit	-0.58	0.562	-1.478	0.139
Improve quality	-2.015	0.044*	-1.137	0.256
Reduces variation	-0.912	0.362	-0.445	0.657
Reduces cost	-0.718	0.473	-0.996	0.319
Improves productivity	-0.211	0.833	-1.268	0.205
Reduces Lead-time	-0.16	0.873	-1.268	0.205
Increases suggestions from the employees	-0.46	0.645	-1.917	0.055
Involves employees	-0.26	0.795	-2.114	0.034*
Increase Customer satisfaction	-0.407	0.684	-0.838	0.402
Decreases Inventory	-1.517	0.129	-1.497	0.134
Creates safety environment	-0.6	0.548	-2.154	0.031*

Note. 2 tailed Significance level on Mann–Whitney test: *P < 0.05; **P < 0.01

4.3.3 Bet system

Additionally, the study investigates the impact on operational performance between companies that employed belt systems and those that did not, were conducted using comparisons for all thirty-three companies by utilizing the Mann Whitney test. The results show a statistically significant difference between companies in terms of improved quality, reduced variation and reduced cost (See Table 8).

Table 8. The results of a comparison between companies that implemented belt systems & companies that did not implement belt systems

Benefit	Belt system	Mean	Z	P-value
Improve quality	Yes	4.67	-2.744	0.006**
	No	4.05		
Reduces variation	Yes	4.42	-1.980	0.048*
	No	3.76		
Reduces cost	Yes	4.67	-2.66	0.008**
	No	3.76		

Note. 2 tailed Significance level on Mann–Whitney test: *P < 0.05; **P < 0.01

These findings support that belt systems produce a higher average of improved quality, reduced variation, and reduced cost

compared to companies that had not employed belt systems within their organization. The results indicate that belt systems can function to improve and increase companies' performance. The utility of the belt system is confirmed by a study that revealed that using a belt system realized significant savings and profits [Harry, 1998; George, 2003]. The remaining factors (P-value > 0.05) such as reduced cost, decreased inventory, improved productivity etc. do not show significant difference between companies executing belt system or not. Thus, it can be concluded that the belt system is useful for improving quality, reducing variation, and reducing cost but shows no other effect in the French industry. This is because; belt systems are related to six sigma methodology, which is focused more sharply on reducing variation and improving quality.

5. CONCLUSION AND FUTURE WORK

Based on the results of this study, it can be concluded that French companies are implementing lean manufacturing and six sigma with significant performance outcomes. These companies show improved quality and reduce variation that applying six sigma to all departments. Companies in the French industry using lean and six sigma have also showed improved profits, quality and performance outcomes generally. The results of this study therefore suggest that companies can improve quality and performance with the implementation lean manufacturing and six sigma practices. However, The belt system appears to be supportive for ensuring that implementation of six sigma is effective. The results of this study also demonstrate that implemented lean manufacturing improves employee participation and involvement and this help to solve the difficulties that are usually associated with implementation in

promoting organizational change for the successful implementation. The results of this also study indicate that company size is a factor in the ability or propensity to implement lean sigma tools and techniques since, the results of this analysis found statistically significance differences in the implementation of lean sigma between SMEs and large companies in four areas of practice. The four areas of practice are, one piece flows, Gemba, DPMO, and DMAIC. In these four areas, large companies have a tendency to use these four tools and techniques on a wider scale than SMEs. The firms should aware and understand of lean and six sigma practices, since these tools and techniques enhance to increase company performance.

The effectiveness of implementing lean manufacturing and six sigma practices is manifested in increased profits, improved efficiency and improved quality. Each of these performance outcomes are accomplished through improvements in reduction of cost, reduction of variances, improved employee involvement, the creation of a safe environment, improved customer satisfaction, elimination of defects in processes and products, improvements in lead times and all other important aspects of total quality management. Overall, statistical analysis shows that the French companies between moderate to extensive deployment on lean manufacturing and six sigma, but the level of implementation varies among organizations. Even though, it has exposed very good results in terms of improved organizational performance. Thus, French companies, have to be more extensive of lean and six sigma implementation. However, it is proposed that in future, to identify the critical success factors of implementing lean manufacturing and six sigma and analyze the factors that lead to successfully of lean and six sigma implementation.

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