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Effect of ISO (9001) Certification and Article Type Produced on Lean Six Sigma Application Successes: a Case Study Within Textile Companies

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Abstract
This study focused on how the ISO 9001:2008 standard has influenced organisational Lean Six Sigma (LSS) implementation success. Data were collected through a survey, followed by interviews with the quality managers/representatives of 85 small and medium enterprises (SMEs) in the textile industry. Additionally, case studies on four of the textile SMEs were carried out to validate the results. Our analysis revealed that the main benefits of LSS, among others, are problem solving improvement, reduction of the quality problem, waste reduction, and increase of productivity. However, certified companies are aware of continuous improvements to tools, which ensures the continuity of improvements made by the LSS project and facilitates the integration of Lean Six Sigma tools, which can help to make better use of the Lean Six Sigma project. The type of article produced was also found to have a considerable effect on the success of the Lean Six Sigma project.

Keywords
Textile SMEs, ISO 9OO1 standard, Lean Six Sigma tools.

1. Introduction

1.1. Lean Six Sigma

Lean Six Sigma is the combined application of two concepts, linking productivity (i.e., Lean) and quality (i.e., Six Sigma). Lean focuses on quickly preparing customer orders, ensuring an affordable price, and gradually improving the quality of products [1, 2]. Six Sigma aims to radically improve the quality of critical processes from the customer's point of view by reducing process variability (i.e., Critical-To-Quality, or CTQ). In Lean, variability is understood qualitatively, whereas Six Sigma makes it possible to quantitatively measure and subsequently control variability [3, 4]. Consequently, the joint application of Lean and Six Sigma allows each of these methods to complement the other and thereby synergistically strengthen their effectiveness to improve the functioning of the organisation [4 - 8]. Indeed, this method is widely used by firms around the world in a variety of different industrial fields that include manufacturing [9 - 13], services [14 - 15], commerce [16], and health care [17-18].

1.2. Standard ISO 9001 and Lean Six Sigma

The International Organization for Standardization (ISO) was established in 1946 in Switzerland with the purpose of developing a set model of international quality assurance standards (ISO 9000) in design, development, production, installation, and service [19]. The ISO quality management system, the most popular internationally, entered a new era with the latest (fourth) revision of the 9001 standard in 2008, which is more customer focused and less biased in favour of the manufacturing sector [20]. The integration of Lean, Six Sigma, and Lean Six Sigma methodologies and tools with the ISO 9001 standard has been examined by numerous scholars. One study presented the effects of Lean thinking on ISO standard documentation and tools [21], while another proposed an integration model using the Six Sigma approach with the ISO 9001 standard to support process management and ensure continual improvements [22]. Some have contended that Lean and ISO 9001 are complementary [23] or have shown a method by which the two could be combined to allow the certification of organisations without the need for any additional documentation [24]. However, there are no previously published studies on the use of LSS tools and methodologies regarding ISO 9001 requirements in textile companies. The present study addresses this gap by examining how ISO 9001:2008 certification and the article type produced impact Lean Six Sigma implementation success in textile SMEs. The data and methodological approach used are presented next in Section 2, followed by a description of the results and discussion of the detection algorithm's implementation in Section 3. Finally, Section 4 presents the conclusion of our research.

2. Methodology

The first stage of this study involved implementing a quantitative survey of a broad sample of small and medium-sized textile enterprises. A questionnaire was distributed to the companies selected, situated in different regions. This questionnaire was followed by direct interviews with the quality managers/representatives of those companies. Then, a qualitative case study was conducted in four textile enterprises to verify the findings from the survey in a real context and to identify the improvements accomplished.

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The quantitative approach began with developing a questionnaire for the survey. To test and validate our questionnaire, it was tested on a small convenience sample of ten firms (five that apply the ISO 9001:2008 standard and five that do not) to ensure the questions' relevance and consistent interpretation, ease of use, narrative flow, and time required. The textile SMEs were identified through the CETTEX database and a full sampling frame was subsequently constructed. There are a variety of techniques that may be employed when sampling potential respondents [25]. We used a simple random sample [26] (Equation 1),

$$n = \frac{z^2 P(1-P)}{e^2 + \frac{z^2 P(1-P)}{N}} \quad (1)$$

where: e = margin of error, N = population size, and z = confidence level. Otherwise, if there are no population data, P = 0.5 may be used, with the result being the maximum sample size given the other assumptions.

In our case, the sample size for a population of 777 SMEs is 85 (textile companies certified by ISO 9001 that have LSS tools and/or methodologies implemented, or companies not certified by ISO 9001 but have LSS tools and/or methodologies implemented). To improve the accuracy of our results, the surveys were followed up by direct interviews with the quality managers/representatives of those companies. Those interviews were conducted in the company for 30-45 min after a telephone appointment.

Table 1 outlines the questions used in the survey questionnaire. Most of the textile companies in the sample are medium (76.1%) and belong to mixed article companies (64.9%), followed by knitted article companies (14.1%) (Table 2). The results were analysed using Excel, and the data were transformed into numbers.

Lastly, to validate our findings on the impact of certification and the textile enterprise's article type on LSS implementation success, a qualitative case study of four textile SMEs was conducted.

Question	Description
Company size	Small: 10 – 80 employees Medium: 80 – 300 employees
Company sector	Technical article companies Knitted article companies Denim article companies Mixed article companies
Certification standard	ISO 9001 Other
LSS tools and methodologies implemented	Installation of balancing production line; calculation of the cycle time ; visual management; 5S; training; just in time; LSS Culture acceptance; Kanban; SMED (single minute exchange of die); VSM (Value Stream Mapping); TPM (total productive maintenance); Kaizen; VOC (voice of the customer); DMAIC (define, measure, analyse, improve, control); FMEA (failure mode and effect analysis); PDCA (plan, do, check, act); Pareto; CTQ (critical to quality); Kano; Identification of bottlenecks.
Critical success factors	The involvement and commitment of top management Performance measurement Communication Organisational culture Availability of resources Training and education Organisational infrastructure Project selection and periodisation Linking LSS to HR reward system Linking LSS to customer
LSS tools improve ISO 9OO1?	None Marginally Significantly A lot
Main improvements with ISO 9001 certification, LSS tools and methods	Reduction of quality problem Cost reduction Waiting reduction Waste reduction Increase of productivity Improvement of problem solving

Table 1. Questionnaire items

	Variable	Percent
Company size	Small: 10 – 80 employees Medium: 80 – 300 employees Total: 77	76,1 % 23,9 % 100 %
Company sector	Technical article companies Knitted article companies Denim article companies Mixed article companies Total: 77	9,9 % 14,1 % 10,9 % 64,9 % 100 %
Certification standard	ISO 9001 Other	20,7 % 10,3 %

Table 2. Sample characterization

3. Result and Discussion

Figure 1 shows that the LSS tools and methodologies most used and implemented in the participating textile companies were the installation of a balancing production line (62%), calculation of the cycle time (57%), visual management (33%), 5S (24%), and PDCA (24%). We also found that a majority (64%) of the textile

enterprises surveyed who applied these tools and techniques were certified with ISO 9001, and among these companies, most (57%) were producers of technical articles. In addition, while all participating textile companies had implemented some lean tools and methodologies, 32.2% had applied four to ten LSS tools or methodologies, and 15.3% more than ten. Therefore, each of the textile companies selected that were certified with ISO 9001 considered the application of LSS methods the most suitable way to achieve successful results. This finding validates that ISO 9001 certification helps LSS tools and methodologies to be more successfully implemented in textile companies.

As Figure 2 shows, the main critical success factors among participants were, 'the involvement and commitment of top management' (96.10%), 'performance measurement' (94.81%), and 'communication' (92.21%).

'Organisational culture' (89.61%), 'availability of resources' (85.71%), and 'training and education' (83.12%) are also mentioned as being high. When we asked if ISO 9001 standard certification produced improvements in the successful implementation of LSS tools and techniques, 90% of the textile enterprises answered positively, and among these 60% indicated that they significantly supported the success of LSS implementation, 25% that the effect was somewhat positive, and 15% stated that the effect was only minor (Figure 3).

The main way that company certification helped the success of LSS tools' implementation was cited as 'problem solving improvement' (62.14%), followed by 'reduction of quality problem' (32.56%), and then 'waste reduction' (31.26%). 'Increase of productivity' (30.47%) and 'cost reduction' (25.34%) were the next highest advantages mentioned by the companies surveyed (Figure 4). Thus, it can be concluded that ISO 9001 certifications can help support organisations in successfully implementing LSS tools and methodologies to achieve production and quality improvements in a variety of ways.

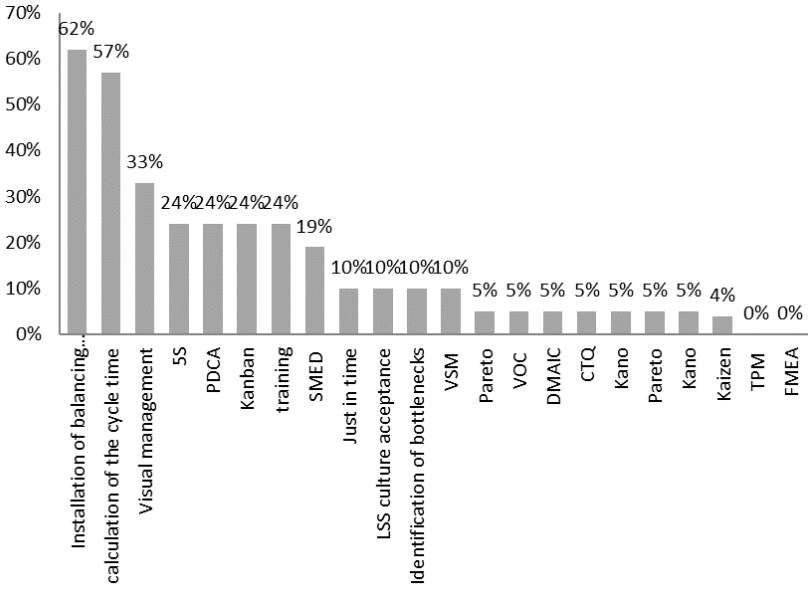

Fig. 1. Main LSS tools and methods applied in the participating textile enterprises

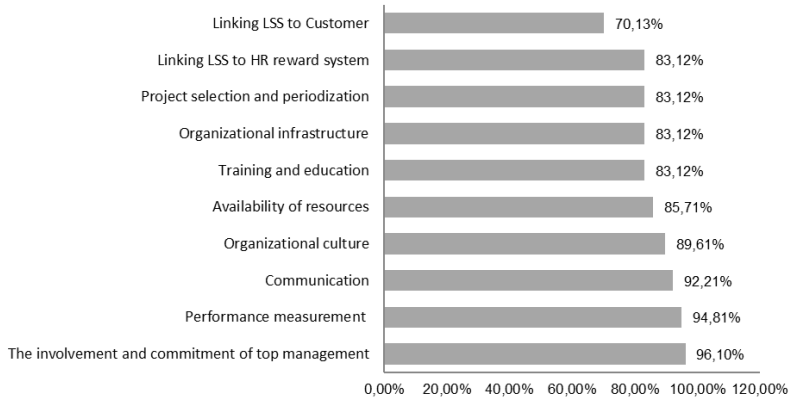

Fig. 2. Main çritical success factors for implementation of LSS

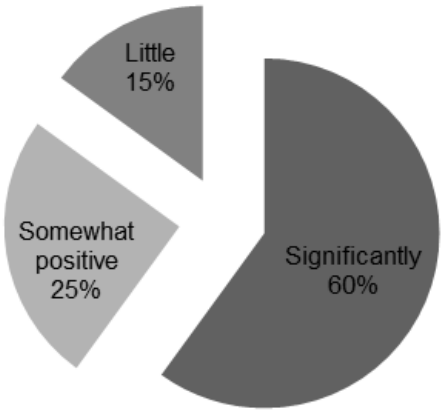

Fig. 3. ISO 9001 standard improves the success of LSS implementation in textile companies

Indeed, the integration of the LSS project with a management system such as the ISO 9001 standard can be considered as a crucial factor for the successful implementation of Six Sigma in an organisation. In the same context, several studies presented the benefits of combining Lean, Six Sigma, and

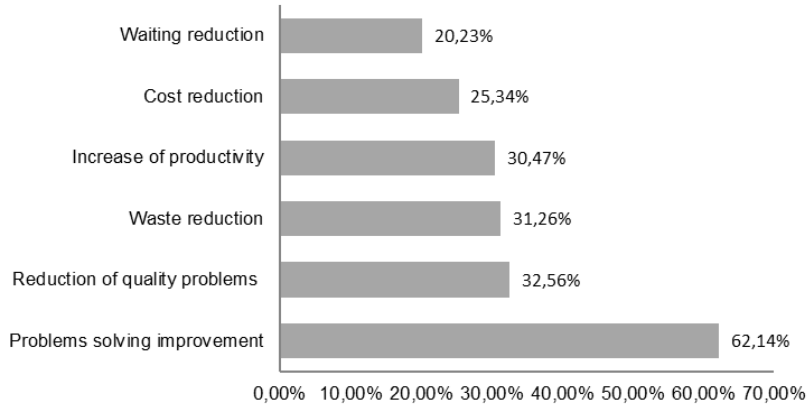

Fig. 4. Main improvements with ISO 9001 certification, LSS tools and methods

SME	Workforce	Sector	Certification
A	35	Technical article (automotive articles)	ISO 9001: 2008
B	75	Technical article (paramedical and orthopaedic articles)	ISO 9001: 2008
C	200	Mixed articles	None
D	201	Mixed article companies	None

Table 3. List of textile SMEs

produced different types of items (denim, technical item, etc.). For example, among those companies, Company C was non-certified and specialised in manufacturing mixed articles.

Table 4 shows the impact of the ISO 9001 standard and the type of article being produced on the application of the LSS project by the various clothing companies. The key indicators used to compare the results before and after implementation of the improvements are Z-Sigma, Cp process capability, cycle time, and non-added value time.

Based on these results, we concluded that the effects of using the LSS project are at their highest when applied in a certified company. Indeed, ISO 9001 certification allows the organisation to better understand its external and internal context, as well as the needs and expectations of customers. Such an understanding facilitates the integration

Key metrics used	A		B		C		D	
	Before improve-ment	After improve-ment	Before improve-ment	After improve-ment	Before improve-ment	After improve-ment	Before improve-ment	After improve-ment
Z-Sigma	2.9	4.15	2	4,68	1.35	2.2	0.7	2
Cp	0.69	1.38	1.47	1.56	0.45	0.96	0.2	1.47
DPMO	80762	4661	308770	967	581814	242071	780000	308538
Cycle time(min)	19.92	19.2	32.4	31	12.78	12.5	10.34	10
non-value added time(min)	18916	15900	17280	13440	16080	16000	10000	9980

Table 4. Comparison of the impact of the certification on the success of LSS project implementation in the different textile SMEs

Lean Six Sigma with ISO 9001 standard requirements [27, 21, 23]. Our study adds to this literature by revealing how the ISO 9001 standard affects the success of the integration of LSS tools and methods in achieving gains in efficiency and productivity for an organisation. According to our survey results, top management was a critical factor for the successful implementation of LSS by ensuring the resources for their support and procedure [28 - 31]. In addition, performance measurements were required to evaluate improvements. However, in our case studies of four textile companies, it was possible to independently verify the impact of the ISO 9001 standard and some of the difficulties the LSS program faced in being implemented.

To verify the impact of the ISO 9001 standard on LSS implementation success, we applied the LSS project in four textile SMEs (Table 3). The LSS project was passed through the sequence of DMAIC steps (define, measure, analyse, innovate, and control).

We also considered the role of article type by examining companies who of Lean Six Sigma tools, which can help to make better use of the Lean Six Sigma project. In addition, certified companies are aware of continuous improvements to tools, such as PDCA. This ensures the continuity of improvements made by the LSS project. The type of article produced was also found to have a considerable effect on the success of the Lean Six Sigma project. For example, for safety articles a requirement is recommended to minimise safety defects. Thus, this type of article requires the use of automated machines, which facilitates the integration of some lean tools and techniques such as Poka-

yoke. In contrast, increasing the Z-Index and the capability of manufacturing processes in companies producing denim articles is not as feasible a task as the probability of defects is high.

4. Conclusion

This study shows how the ISO 9001 standard positively influences the implementation success of LSS tools and methodologies in textile companies by presenting the main benefits provided by ISO 9001 certification. We established that all the participating textile companies had some Lean Six Sigma tools and methodologies implemented. Each textile company implements these tools based on what they consider the most appropriate to accomplish the best results. Therefore, the choice of Lean Six Sigma tools for textile companies must be based on which tools and techniques are most efficient to guarantee the maximum speed, simplicity, and flexibility of results. Each company must decide for itself which of the tools, techniques, and indicators of Lean Six Sigma to apply based on its actual capabilities, needs, size, customer requirements, and type of article manufactured. 90% of the textile companies surveyed agree that ISO 9001 standard certification supports the implementation of LSS tools and methods by improving their effectiveness, with 62.14% of the organisations indicating 'problem solving improvement' as the main benefit, followed by 'quality problem reduction' (32.56%) and 'waste reduction' (31.26%). This finding validates the impact of the ISO 9001 standard and the article type produced on LSS implementation success.

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Declaration of conflicting interests

The Authors declare there is no conflict of interest

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