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In search of Six Sigma in Portuguese SMEs

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Abstract

This exploratory research aims to study the reasons for the low implementation level of Six Sigma within Portuguese Small and Medium Enterprises. The results suggest that ISO 9001 certification, and Lean Management, are still regarded as enough for company success. The descriptive analysis and the statistical tests performed led to the conclusion that there are no significant differences for the motivations not to implement Six Sigma between small and medium companies. The qualitative research with focus groups highlighted that SMEs aiming for fast improvement results focus more on Lean Management and Kaizen, by using Five S methodology, visual management at shop floor level and basic quality tools. However, there are different views concerning Six Sigma applicability and value for SMEs, suggesting the need for further in depth research. Within this context, the edition of ISO 9001:2015 International Standard with an increased emphasis on process approach and the achievement of the quality management system objectives is a relevant opportunity for using Six Sigma to streamline processes and enhance customer satisfaction and business results.

Key words: *Quality management systems (QMS), Quality management techniques; Six Sigma, Small and Medium Enterprises (SMEs).*

1. INTRODUCTION

Many companies face today a global and complex competitive environment. To be successful, they need to create value, by applying sound and proven management approaches.

Since Six Sigma come to life in the 1980s in the USA, it has been applied with quite positive results in companies like Motorola [1] and General Electric [2]. However, Six Sigma application both in Portuguese companies [3, 4] and in Small and Medium Enterprises (SMEs) has never been extensive [5]. Following a major literature review, researchers such as Aboelmaged [6] support the view that further investigation about Six Sigma is needed. Additionally, the release of the 2015 edition of ISO 9001 International Standard represents an opportunity for companies to revitalize their quality management systems (QMS), and to consider applying Six Sigma.

In this exploratory research, we aim to study with a hybrid qualitative (survey) and quantitative (focus group) approach, the reasons for the non-application of Six Sigma in Portuguese SMEs.

These are very relevant companies for value creation and employment representing 99% of Portuguese companies (excluding firms providing financial services, such as banks, investment funds, and insurance companies). The 2012 Excellence SMEs recognized by the Portuguese IAPMEI (Public Agency for Competitiveness and Innovation) were selected for this research population
due to its economic stability and access to contacts. The conclusions were reached through descriptive statistics, hypothesis testing and focus groups interviews.

Since many Portuguese SMEs have a high exporting profile, the results of this research could be of interest to similar companies from other countries.

2. LITERATURE REVIEW

2.1. Six Sigma

Six Sigma is a total quality management tool [7] (based on a disciplined approach for dramatically reducing defects and producing measurable financial results [8,9] and is much more than its technical meaning of a failure rate of 3.4 parts per million. Other definitions of Six Sigma are more oriented toward methodologies e.g. DMAIC-Define, Measure, Analyse, Improve and Control for effectiveness improvements [10], Lean Six Sigma for effectiveness and efficiency improvements, DFSS- Design For Six Sigma using DMADV- Design, Measure, Analyse and Improve for incremental improvements and IDOV- Identify, Design, Optimize and Validate for radical improvement [11]. There are also Six Sigma definitions as a metric to measure the variation and process capability, e.g., measuring processes in terms of their DPMO (defects per million

opportunities), critical-to-quality (CTQ), or process sigma, highlighting the importance of process and product improvement and establishing difficult but attainable goals. Six Sigma definition as a management system approach will be used as base for this research, and incorporates the other definitions emphasizing that it should not be a simple quality technique or statistical tool, but rather a strategic management approach supporting key projects aligned with the business goals and the customer requirements [6]. This will be the framework used for this research. The Six Sigma frameworks (DMAIC, DMADV and IDOV) share the feedback loop with other quality management frameworks such as the PDCA cycle (plan, do, check, and act) [12]. More than the use of quality techniques or principles, it is the deployment approach and the emergent structure that represents Six Sigma novel contributions to the quality management discipline and support the definition of Six Sigma as management system approach [13]. And the improvement is made on a project basis in line with the prescription from Juran [14] that "improvement happens project-by-project and in no other way." Table 1 bellow outline the main alternatives for using Six Sigma frameworks:

Table 1. Major six Sigma frameworks (Author elaboration)

Product or process situation	Framework
Existing, no need for new design, incremental improvement enough	DMAIC
Existing, need for radical improvement, no need for new conceptual solution	DFSS/DMADV
Existing, need for radical improvement, need for a new conceptual solution	DFSS/IDOV
New product or process	DFSS/IDOV

ISO International Standard ISO 13053 series [15, 16] present recommendation on training for each Six Sigma team member and the number of days needed to achieve these goals.

Cooperation and alignment towards common goals between all Six Sigma team members are also keen for the project success. Figure 1 summarizes the proposed structure for Six Sigma applications:

Several authors have studied the relevant factors for Six Sigma project success [3, 17, 18, 19 and 20]. In addition to Six Sigma training, top management commitment, the use of Six Sigma as a strategic tool with key projects aligned with the organization strategy, the identification of the projects return of investment and the appropriate soft skills of the teams' members are amongst the most relevant success factors.

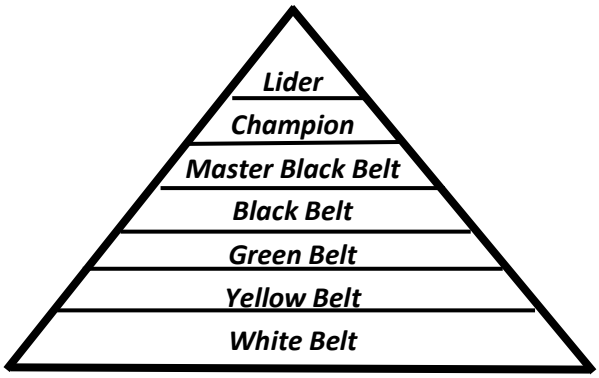

Figure 1. Six Sigma Overall Structure (Source: ISO, [15, 16])

Concerning the factors that have the most impact on the lack of Six Sigma success those include not fulfilling the previous conditions, like lack of top management commitment, disconnection with strategy and inability to perform a cultural change.

2.2 **Six Sigma and SMEs**

Since Motorola started to apply Six Sigma several big companies have implemented it. According to Snee and Hoerl [21]) there are no specific reasons for not applying Six Sigma at SMEs.

Wilson [22] considers that being smaller in size, SMEs have increased agility, and with top management commitment and support, the implementation of Six Sigma with positive results should be easier.

However, only few cases of Six Sigma application in SMEs have been presented and the literature review points out for the following possible reasons (see Table 2 below):

Table 2. Contributing factors for difficulties in implementing Six Sigma in SMEs (source: Author elaboration)

Authors	Factors
Nonthaleerak and Hendry [20]	• Considerable investment needs.
Antony [23]	• It is difficult to choose between the many programs available: Six Sigma, TQM, ISO, EFQM and the one that best suits the SMEs needs; • ISO 9001 QMS are considered enough; • Lack of success stories; • Lack of Top Management commitment and Six Sigma understanding; • There is a wrong idea concerning the high statistical level of difficulty required for Six Sigma.

Table 2. Contributing factors for difficulties in implementing Six Sigma in SMEs (source: Author elaboration)

Raghunath and Jayathirtha [24]	• Lak of resources; • Resistance to change; • Poor Top Management leadership; • Lack of Six Sigma knowledge and training; • Department and cultural barriers; • Idea that Six Sigma is too complex; • Wrong choice of process parameters; • Failures in data collection; • Poor choice of Six Sigma projects.

In summary, there are several reasons that might lead SMEs not to adopt Six Sigma, such as lack of resources, poor knowledge, and inadequate leadership.
Previous studies about Six Sigma adoptions by Portuguese companies have shown that Six Sigma use in Portuguese companies is approximately 10 to 8% [3, 4]. In Brazil, Andrietta and Miguel [25] identified that Six Sigma utilization reached its top level in 2000, due to benefits of major companies, which triggered the use of Six Sigma in Brazil. In the United Kingdom, Antony [23] confirmed that 27% of SMEs were implementing Six Sigma, although very recently started. The literature on Six Sigma in Portuguese SMEs is very limited, representing a relevant research opportunity to address this gap.

2.3. **ISO 9001**

ISO first published the ISO 9000 series of International Standards© (www.iso.org) back in 1987, supporting the growing internationalisation of business, and the need for common QMS standards. Although ISO 9001 International Standard cannot be considered as a Total Quality Management (TQM) Model it does indeed incorporate many of the principles of these models and can be considered as a step towards that direction. There are common dimensions between ISO 9001 International Standards and TQM (e.g., process management) however companies that implemented and certified their ISO 9001 Management Systems would still fall far short of implementing a comprehensive TQM system [26]. ISO 9001:2015 edition closes the gap between ISO and TQM and is more in line with present business models. It has an increased emphasis on process approach and the achievement of the quality management system objectives and new or reinforced approaches, like consideration of organisational context, (relevant) stakeholders, risk-based thinking, and knowledge management [27].
ISO 9001 International Standard can be an excellent complement to Six Sigma if it is interpreted in a way that encourages the company to begin the process of continual improvement and aligns its entire people toward that goal. By exploiting the relationships between Six Sigma and quality management systems (QMS) based on the ISO 9001 International Standard both approaches can be combined and integrated in a systematic way [28].
In Portugal, regardless of organisation type and sector, ISO International Standard ISO 9001:2008 is widely used. According to ISO Survey 2015 (www.iso.org) there were in 2014, more than 8.000 certified organisations with ISO 9001:2008. Government policies promoting both quality management and an institutional positive attitude to ISO 9001 are likely to be two important factors for this phenomenon [29]. The intensity of trade has also been highlighted as a major reason for a country high ISO 9001 certification intensity [30, 31].
For a given country, population and gross national income have been identified as two significant variables that influence the quality management systems certification diffusion [32]. Portugal has a relatively high ISO 9001 certification intensity (e.g. measured in the number of certificates per million habitants, or the number of certificates per capita gross national income), driven by its geographic position and the European Union membership, favouring international trade, and the European Union and Portuguese Government policies supporting ISO 9001 certification.
Authors such as Marques et al. [28] have analysed the relationships between Six Sigma ISO 9001 based QMS and proposed guidelines to systematically integrate both approaches. The conceptual integration model aims to align Six Sigma projects with ISO 9001 QMS policies and objectives, to foster process management and continual improvement and to establish effective relationships between the organizational structures needed to support both Six Sigma and ISO 9001 QMS.

2.4 **Lean Production**

Lean production or lean thinking is based on the concept of reducing waste (muda) to achieve cost effective improvements. The concept of muda originated by Taiichi Ohno's production philosophy known as the Toyota production system in Japan and it became later as lean production and lean thinking [33, 34, 35].
The word Kaizen is made of two Japanese words "kai" which means change and "zen" which means for the better. After World War II, Japanese Industry adopted Kaizen to increase their competitiveness, with Toyota Motor Company as a major example. They focused on incremental improvement with low-cost solutions and employee participation with emphasis on process improvement rather than the result [36]. 5S also has its origins in Japan in connection with Kaizen methodology through the integration of seiri (sort what is not needed), seiton (systematic arrangement, strengthen what must be kept, make things visible), seiso (clean), seiketsu

(standardize - state the rules) and shitsuke (self-discipline, follow rules) [37].
While the concept of Lean is more familiar in the West and the concept of Kaizen in Japan, both approaches are based on the elimination of waste by continuous improvement in term of costs, quality, flexibility [38] and productivity [39]. Kaizen focuses on Muda (waste), Mura (discrepancy) and Muri (strain) and an umbrella of tools and techniques can be applied, such as 5Ss, VSM (Value Stream Mapping), Cause and Effect Diagrams, Histograms, Heijunka (levelled production), Jidoka (quality at the source), TPM (Total Preventive Maintenance), JIT (Just-inTime), TQC (Total Quality Control), SMED (Single Minute Exchange Die) and the suggestion system [36].
Although there are no comprehensive studies on the extent that Lean and Kaizen are used by Portuguese SMEs, the increasing number of communications and case studies
in Portugal, are indications that these approaches are used as a cost-effective and proven results improvement process by Portuguese organizations.

3. RESEARCH METHODOLOGY

The research objectives have taken into consideration the literature review findings and the object of study, focusing on Six Sigma application in Portuguese SMEs. A hybrid research methodology, combining quantitative (survey) and qualitative (focus group) research was used for this investigation. The survey was developed using as reference Alsmadi [40] and Antony [23] and Google Docs software, with closed questions and a *Likert* 1-5 scale.
The questionnaire consisted of four groups of questions. In the first group, the aim was to collect general information related to the respondent company and the respondent person. In the second group, the aim was to gather information on Six Sigma knowledge, available company resources and competencies for Six Sigma, motivations, and benefits. The third group had the objective of understanding the reasons for not implementing Six Sigma in the company and the last group of questions was dedicated for follow-up contact.
The sample basis for this research was made of Portuguese companies awarded SMEs Excellence status by IAPMEI (Portuguese Public Agency for Competitiveness and Innovation (http://www.iapmei.pt/index.php). A pre-test was carried on with the aim of identifying the issues that needed to be improved by reviewing it with Portuguese consultants specialized in Six Sigma Based on the suggestions and comments collected during the pre-test phase, the questionnaire was improved and its final version was sent to 1033 Portuguese 2012 Excellency SMEs with valid emails in June 2014. After one month, 62 valid replies were received (estimated response rate of 6%, based on the number of emails sent). We acknowledge this is a small sample size and future research with increased sample sizes and additional segmentation should be carried for additional representation and increased statistical validity.
Microsoft Excel 2007 and Statistical Package for the Social Sciences (SPSS) Version 22 were used for the subsequent statistical analysis and hypotheses testing were performed to draw conclusions in this research.
After the analysis of the quantitative data, a qualitative approach was used with two focus groups of five experts each that reflected on the survey results and presented their view concerning Six Sigma adoption by SMEs.
From these two contrasting groups, one represented the Six Sigma Black Belt voice and other Non-Six Sigma Quality Managers adopters (that considered using Six Sigma but decided not to apply it).
The final conclusions were outlined from both the qualitative and the qualitative approaches.

4. RESULTS

The literature review highlighted several reasons that might lead smaller companies not to implement Six Sigma, such as insufficient resources, no success stories, poor leadership, and lack of knowledge. To test if there were significant differences due to company size concerning the reasons for not implementing Six Sigma, two groups were considered: companies with 1 to 49 employees (“small companies”) and companies between 50 and 249 employees (“medium companies”).
Statistics results were analysed followed by hypotheses testing. It was confirmed there was no missing data yielding 62 valid responses. ISO 9001 was the most common implemented management system standard (48% had ISO 9001 certification), and 12% had implemented other standards (40% with no implemented management system standard). Concerning the individual respondents, 44% were quality managers, 23% CEOs, and the others had various functions.
A total of 87% held university degrees however, 58% stated that they had insufficient Six Sigma knowledge. None of the 62 companies had implemented Six Sigma, mainly because they consider that ISO 9001 certification was enough for the moment and/or they already had satisfactory improvement processes, such as Lean or Kaizen. However, 71% considered the possibility of implementing Six Sigma in the future.
The survey asked for inputs concerning the adequacy of Six Sigma to SMEs and half the answers was “neither agree/neither disagrees”, while 45% of the respondents agreed that Six Sigma is adequate for SMEs and only 4% answering not adequate.
The descriptive statistics for the “Reasons for not implementing Six Sigma” by “Company Size” are presented in Table 3, for the each of the 9 reasons identified according to the literature review, and for the two SMEs company size category “small companies” (1 to 49 employees) and medium companies (50 to 249 employees):

Table 3. Summary of Descriptive Analysis by company size (source: Author elaboration)

Company Size (range of number of workers)	Motivation	Mean Value	Standard Deviation
1 - 49	Lack of knowledge concerning methodology, tools, and techniques	3,00	1,225
50 - 249		3,14	1,153
1 - 49	Problems in understanding methodology, tools, and techniques	2,59	1,048
50 - 249		2,81	1,078
1 - 49	Lack of financial resources	2,54	0,977
50 - 249		2,33	0,966
1 - 49	Lack of Human resources	3,02	1,060
50 - 249		3,00	1,000
1 - 49	Lack of technological resources	2,68	0,907
50 - 249		2,86	0,854
1 - 49	There is already satisfactory improvement process in place (Lean, Kaizen)	3,34	0,965
50 - 249		3,48	0,873
1 - 49	The existing management systems are already adequate	3,29	1,101
50 - 249		3,67	0,913
1 - 49	Satisfaction with actual quality levels	3,44	1,097
50 - 249		3,43	1,028
1 - 49	Not applicable to the company	2,71	1.055
50 - 249		2,86	0,793

By analysing Table 2 we conclude that the results are similar between the two company size groups. However, for the “50 – 249 workers” group (medium companies) the main motivation for not implementing Six Sigma is “The existing management systems are already adequate”, while for the “1-49 workers group” (small companies) is “Satisfaction with actual quality levels”. For both groups, “Lack of financial resources” was reported has not so relevant.

Since the weight of the motivation not to implement Six Sigma might change with company size, two research hypotheses were formulated to check if this difference is statistically significant:

- H0: The level of importance of the motivations that lead to the non-adoption of Six Sigma is the same between the two groups;
- H1: The level of importance of the motivations that lead to the non-adoption of Six Sigma is different between the two groups.

Sample normality was tested with Kolmogorov-Smirnov and Shapiro-Wilk Tests. It was confirmed the data did not present a normal distribution, so U Mann-Whitney Test (non-parametric tests) were applied by using SPSS Independent Samples Mann-Whitney U Test. The Mann-Whitney U test was used to understand whether the importance level of each of the nine motivation that lead to the non-adoption of Six Sigma (the dependent variable), differed based on company size (the independent variable), which has two groups: “small companies” (1 to 49 workers) and "medium companies” (50 to 249 workers).

Table 4. Summary of Hypotheses Test (source: Author elaboration)

Number	Null Hypothesis	Sig
1	The distribution of lack of knowledge concerning methodology, tools, and techniques is the same for small and medium companies	O,694
2	The distribution of problems in understanding methodology, tools and techniques is the same for small and medium companies	0,377
3	The distribution of lack of financial resources is the same for small and medium companies	0,470
4	The distribution of lack of Human resources is the same for small and medium companies	0,944
5	The distribution of lack of technological resources the same for small and medium companies	0,368
6	The distribution of there are already satisfactory improvement process in place (Lean, Kaizen) is the same for small and medium companies	0,474
7	The distribution of the existing management systems are already adequate is the same for small and medium companies	0,162
8	The distribution of satisfaction with actual quality levels is the same for small and medium companies	1,000
9	The distribution of not applicable to the company is the same for small and medium companies	0,584

For all tests: Independent Samples Mann-Whitney U Test
Asymptotic significances are displayed. The significance level is 0.05
Decision for all tests: Retain the null hypothesis.

After analysing these results, the null hypothesis cannot be rejected. With a 95% confidence level, we can state that, for each of the nine hypotheses, that the level of importance of the motivation that led to the non-adoption of Six Sigma is the same between the two groups (small and medium companies).
Following the quantitative analysis, a qualitative approach with two focus groups was carried out, through open discussions concerning the survey results and the applicability and value of Six Sigma for SME. These two groups represented two major cluster with contrasting views; the Six Sigma Black Belt Experts and

the Non-Six Sigma Adopters Quality Managers. The outputs of these two focus groups, that gathered in the end of 2015, are summarized in table 5 below:

Table 5. Focus Group position concerning Six Sigma Adoption

Six Sigma Experts (5 Six Sigma Black Belt)	Non-Six Sigma adopters (Five Quality Managers from SMEs that have evaluated and decided not to adopt Six Sigma)
• Both Six Sigma and ISO 9001 QMS are process-based approaches aiming for business improvement • Six Sigma has a scientific basis and is key to reduce process variation and achieve the desired results • Six Sigma relies on a project by project approach, with measurable outputs and outcomes • Six Sigma criteria for project selection is a key contributor to the achievement of organizational goals • Six Sigma structure is a proven effective support for an organizational culture based on innovation and improvement • ISO 9001 is a management system approach, but alone is too generic and lacks appropriate tools and techniques • Lean and Kaizen methodologies can minimize waste but do not provide enough process knowledge for sustainable and profound improvement	• ISO 9001 is required by the market and is the most common approach for Quality improvement in our market • Lean and Kaizen Management with the use of methodologies that can be understood by our employees are the most effective approaches to achieve quick wins and embrace all our workforce in process improvement • Visual management at shop floor and the use of basic tools such as Histograms, Pareto charts and Cause and Effect diagrams are effective tools than can be understood and applied by all • Six Sigma requires competencies in a set of statistical concepts and tools that are difficult to master • Six Sigma is not presently used in our industry by similar companies, is mainly applied by big US corporations • The main priority of our companies is the transition to ISO 9001:2015, after that, we might reevaluate the opportunity to use Six Sigma

5. CONCLUSION

This study highlights the major reasons why Portuguese SMEs are not implementing Six Sigma and found no statistical significant for two group companies with different size, the small and the medium companies:

- The respondents considered that they already had implemented satisfactory improvement processes with the existing management systems and that their actual quality levels were satisfactory;
- Lack of knowledge concerning methodology, tools, and techniques and of human resources was also emphasized as reasons for not having yet implemented Six Sigma.

Concerning the results of the two focus groups, while the Six Sigma Experts consider it necessary for company success and claim to have the data to support their statements, the Non-Six Sigma adopters are more focused on ISO 9001:2015, complemented with less complex Lean and Kaizen approaches. However, the two contrasting groups agreed that there are synergetic opportunities for Six Sigma, ISO 9001, and Lean/Kaizen, has companies strive for increased process and product improvements.

The results confirm the works of Alsmadi [40], Antony [5] and Fonseca et al. [4] that lack of Six Sigma knowledge is a major source for SMEs not implementing this methodology. In Portugal, the economic slowdown between 2012 and 2014 also represented a considerable work overload to some key company people.

This could add to the perception that ISO 9001 QMS or even basic improvement activities are enough to assure quality, productivity, and companies' competitive position. Since 71% of the respondents considered the possibility of implementing Six Sigma in the future it would be important to monitor if this intention materializes into actions and results.

This investigation contributes to the Six Sigma body of knowledge with an emphasis on SMEs. Concerning the company sizes, it was expected that smaller companies should report stronger reasons for not implement Six Sigma than medium companies, since they usually lack some of the resources of bigger companies. However, this was not statistically confirmed.

The research results also bring more attention to the need for strengthening Six Sigma formal education curricula and training, leading to a much more intense implementation of this proven effective and competitive improvement methodology. The opportunity to integrate Six Sigma within ISO 9001:2015 QMS was also emphasized. And last, but not least, there are indeed different views concerning Six Sigma applicability and value, so further research is still needed.

As practical contributions, managers should evaluate if their organisation is pleased with the present QMS. If the QMS is not a lean process based system and it does not integrate and supports the business well, they should consider Six Sigma. It could be a relevant opportunity to review and reignite their systems by exploiting the relationships between Six Sigma and QMS and the new approaches of the ISO 9001:2015 edition.

This study has several limitations that should be acknowledged. The small sample size could not be representative of the universe of Portuguese companies. More segmented studies by sector of activities and higher company size discrimination (e.g., including bigger companies) should be carried out. The

qualitative approach could be a good research strategy to overcome the sample ample sizes and might be strengthened with more elaborated approaches such as grounded theory and content analysis.

6. REFERENCES

[1] Harry, M. and Schoeder, H. (1998), "Six Sigma: a breakthrough strategy for profitability", Quality Progress, Vol. 31, No. 5, pp. 60-64.

[2] Henderson, K. and Evans, J. (2000), "Successful implementation of Six Sigma: benchmarking General Electric Company", Benchmarking and International Journal, Vol. 7, No. 4, pp. 260-281.

[3] Conceição, A.C. and Major, M.J. (2011). "Adoção do Six Sigma pelas 500 Maiores Empresas em Portugal". Revista Brasileira de Gestão de Negócios, Jul/Set. 2011, pp. 312-331.

[4] Fonseca, L., Leite, D. and Lima, V. (2014), "Six Sigma Methodologies Implementation and impacts on Portuguese SMEs", International Journal for Quality Research, Vol. 4, pp. 583–594.

[5] Antony, J. (2008), "Reflective Practice - Can Six Sigma be effectively implemented in SMEs", International Journal of Productivity and Performance Management, Vol. 57, No. 5, pp. 420-423.

[6] Aboelmaged, M.G. (2010),"Six Sigma quality: a structured review and implications for future research", International Journal of Quality & Reliability Management, Vol. 27, No. 3, pp. 268–317.

[7] Odendaal, C.E. and Claasen, S. J (.2002), "Six Sigma as a Total Quality Management Tool", South African Journal of Industrial Engineering, Vol. 13, No. 1, pp. 25-33.

[8] Linderman, K., Schroeder, R., Zaheer, S. and Choo, A. (2003), "Six Sigma: A goal theoretic perspective", Journal of Operations Management, Vol. 21, No. 2, pp. 193–203.

[9] Anand, G. (2006), *Continuous Improvement and Operations Strategy: Focus on Six Sigma Programs,*The Ohio State University.

[10] McAdam, R. and Lafferty, B. (2004), "A multilevel case study critique of Six Sigma: statistical control or strategic change?", International Journal of Operations and Production Management, Vol. 24, Vol. 5, pp. 530-549.

[11] McCarty, T., Bremer, M., Daniels, L. and Gupta, P. (2004), *Six Sigma Black Belt Handbook,*The McGraw-Hill Companies.

[12] Senapati, N.R. (2004), "Six Sigma: Myths and realities", International Journal of Quality & Reliability Management, Vol. 21, No. 6, pp. 683-690.

[13] Schroeder, R.G., Linderman K., Liedtke C. and Choo, A.S. (2008), "Six Sigma: Definition and underlying theory", Journal of Operations Management, Vol. 26, pp. 536–554.

[14] Juran, J.M. (1989), *Leadership for Quality: An Executive Handbook*, The Free Press, New York, NY.

[15] International Organization for Standardization. (2011), *ISO 3053-1:2011, Quantitative methods in process improvement - Six Sigma - Part 1: DMAIC methodology*. Geneva, ISO.

[16] International Organization for Standardization (2011), *ISO 13053-2:2011, Quantitative methods in process improvement - Six Sigma - Part 2: Tools and techniques*. Geneva, ISO.

[17] Antony, J. and Banuelas, R. (2002), "Key ingredients for the effective implementation of Six Sigma program", Measuring Business Excellence, Vol. 6, pp. 20-27.

[18] Chang, T.L. (2002), *Six sigma: framework for small and medium-sized enterprises to achieve total quality*., Cleveland, EUA: Cleveland State University.

[19] Kwak, Y.H., Anbari, F.T. 2006. Benefits, obstacles, and future of six sigma approach. Technovation, 26, pp. 708-715.

[20] Nonthaleerak, P., and Hendry, L. (2006), "Six Sigma: Literature review and key future research areas", International Journal of Six Sigma and Competitive Advantage, Vol. 2, No. 2, pp.105-161.

[21] Snee, R. and Hoerl, R. (2003), *Leading Six Sigma - A Step by Step Guide based on Experience at GE and Other Six Sigma Companies.* NJ, USA: FT Prentice-Hall.

[22] Wilson, N. 2004. "*The small company and six sigma: advantages of small business culture*", Available at http://www.sixsigmaforum.com/protected/articles/, (accessed: 09 July 2008).

[23] Antony, J. (2008), "Reflective Practice - Can Six Sigma be effectively implemented in SMEs", International Journal of Productivity and Performance Management, Vol. 57, No. (5), pp. 420-423.

[24] Raghunath, A., and Jayathirtha, R.V. (2013), Barriers for implementation of Six Sigma by Small and Medium Enterprises, International Journal of Advancements in Research & Technology, Vol. 2, No. 2, pp.1-7.

[25] Andrietta, J.M. and Miguel, P.A. (2007), "Aplicação do programa Seis Sigma no Brasil: Resultados de um levantamento tipo survey exploratório-descritivo e perspetivas para pesquisas futuras", Gestão & Produção, Vol. 14, No. 2, pp. 203-219

[26] Martínez-Costa, M., Choi., T.Y., Martínez, J.A. and Martínez-Lorente, A.R. (2009), "ISO 9000/1994, ISO 9001/2000 and TQM: The performance debate Revisited", Journal of Operations Management, Vol. 27, No. 6, pp.495–511.

[27] Fonseca, L. (2015), "From Quality Gurus and TQM to ISO 9001:2015: a review of several quality paths", International Journal for Quality Research, Vol. 9, No. 1, pp.167– 180.

[28] Marques, P. Requeijo, J., Saraiva, P. and Frazão-Guerreiro, J. (2013), "Integrating Six Sigma with ISO 9001", International Journal of Lean Six Sigma, Vol. 4, No. 1, pp. 36-59.

[29] Dick, P.M.G., Iñaki, H and Casadesús, M. (2008), "Shedding light on causation between ISO 9001 and improved business performance", International Journal of Operations & Production Management, Vol. 28, No. 7, pp. 687-708.

[30] Corbett, C.J. and Kirsch, D.A. (2004), "Response to revisiting ISO 14000 diffusion: a new look at the drivers of certification", Production and Operations Management, Vol. 13, No.3, pp. 268-71.

[31] Potoski, M. and Prakash, A. (2009), "Information asymmetries as trade barriers: ISO 9000 increases international commerce", Journal of Policy Analysis and Management, Vol. 28, No.2, pp. 221-238.

[32] Saraiva, P. and Duarte, B. (2003), "ISO 9000: some statistical results for a worldwide Phenomenon", Total Quality Management & Business Excellence, Vol. 14, No. 10, pp. 1169-1178.

[33] Womack, J.P., Jones, D.T. and Roos, D. (1990), *The Machine that, Changed the World,* Maxwell Macmillan International, New York, NY.

[34] Womack, J.P. and Jones, D.T. (1996), *Lean Thinking – Banish Waste and Create Wealth in your Corporation*, Simon & Schuster, London.

[35] Udagawa, M., Satoo, H., Nakamura, K. and Nonaka, I. (1995), *Nihon Kigyoono Hinshitsu Kanri (Quality Management in the Japanese Enterprises)*, Yuhikaku, Tokyo (in Japanese).

[36] Imai, M. (1986), *Kaizen: The Key to Japan's Competitive Success,* New York: McGraw-Hill.

[37] Osada, T. (1991), *The 5S's: Five Keys to a Total Quality Environment,* Asian Productivity Organization, Tokyo

[38] Bessant, J., Caffyn, S., and Gilbert, J. (1994), "Mobilizing continuous improvement for strategic advantage", EUROMA, Vol.1, 175-180.

[39] Choi, T.Y., Rungtusanatham, M. and Kim, J.S. (1997), "'Continuous improvement on the shop floor: lessons from small to midsize firms', Business Horizons, Vol.40, No.6, pp.45-50.

[40] Alsmadi, M., Lehaney, B., and Khan, Z. (2012), "Implementing Six Sigma in Saudi Arabia: An empirical study on the fortune 100 firmsS", Total Quality Management, Vol. 23, No. 3, pp. 263-276.

U potrazi za Six Sigma u portugalskim MSP

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Apstrakt

Ovo istraživanje ima za cilj da prouči razloge za nizak nivo implementacije Six Sigma u portugalskim malim i srednjim preduzećima (MSP). Rezultati pokazuju da se ISO 9001 sertifikacija i Lean menadžment, i dalje smatraju dovoljnim za uspeh preduzeća. Deskriptivna analiza i izvedeni statistički testovi ukazuju da ne postoje značajne različitosti između malih i srednjih preduzeća koje utiču da se koncept Six Sigma ne primenjuje. Kvalitativna istraživanja ukazuju na činjenicu da se mala i srednja preduzeća više fokusiraju na Lean menadžment i Kaizen, koristeći 5S metodologiju, vizuelni menadžment i primenu osnovnih alata kvaliteta sa ciljem brzog postizanja rezultata. Međutim, postoje različita mišljenja po pitanju vrednosti i primenljivosti koncepta Six Sigma u malim i srednjim preduzećima, što ukazuje na potrebu daljeg, detaljnijeg istraživanja. U tom kontekstu, novo izdanje ISO 9001:2015 međunarodnog standarda sa povećanim naglaskom na procesni pristup i postizanje ciljeva sistema menadžmenta kvalitetom predstavlja relevantnu priliku za primenu Six Sigma koncepta kako bi ubrzali procese, povećali zadovoljstvo kupaca, kao i efikasne poslovne rezultate.

Ključne reči: *Sistemi menadžmenta kvalitetom (SMK), tehnike menadžmenta kvalitetom; Six Sigma, mala i srednja preduzeća (MSP).*