

Comparative Analysis between Lean, Six Sigma and Lean Six Sigma Concepts

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ABSTRACT

This paper analyzes the benefits of Lean Six Sigma in comparison with Lean and Six Sigma, traditional improvement methodologies. The introduction highlights the appearance of Lean Six Sigma, early 2000s, as well as the benefits brought by the integrated approach. The following parts of the study emphasize the main differences between methodologies and their commonalities based on their synergy. Finally the advantages of Lean Six Sigma versus Lean and Six Sigma are analyzed and systematized by author in order to reveal Lean Six Sigma's benefits.

KEYWORDS: *Lean, Six Sigma, Lean Six Sigma*

JEL CLASSIFICATION: *L10, L20, M10, M20, O30*

1. INTRODUCTION

First mentioned by George (2002) the Lean Six Sigma concept was quickly spread worldwide and widely used as a heavily management tool for improving organizations' performances. Lean Six Sigma, result of the fusion of Lean and Six Sigma, integrates all the strong points of the two methodologies and has all their advantages. Lean Six Sigma drives to process improvement, saving costs and increasing business competitiveness, focusing on customer and based on management commitment and employee engagement.

According to Antony (2011) the integration of two systems can achieve better results than what either system could not achieve alone. The integrated approach works better than previous approaches because it integrates the human and process aspects of process improvement. Furthermore, Psychogios, Atanasovski and Tsironis (2012) conclude that customer satisfaction should be the guiding principle for two main factors: quality-driven strategic orientation and quality-driven corporate culture.

This paper intends to highlight the benefits of Lean Six Sigma compared with the advantages of other two improvement methodologies, i.e. Lean and Six Sigma. Differences and commonalities between Lean and Six Sigma are presented, as revealed in literature and as seen by the author, within a large comparison between methodologies underlying the benefits of Lean Six Sigma. The paper points out that Lean Six Sigma is based both on the strengths specific to each methodology, but also on the strengths common to Lean and Six Sigma and from this point of view their merger could be seen as better than both ones.

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2. OBJECTIVE AND METHODOLOGY OF RESEARCH

The article aims to make a critical comparison of the three optimization methodologies, i.e. Lean, Six Sigma and Lean Six Sigma, which appeared in chronological order at different moments of time. Studying Lean and Six Sigma differences and commonalities could be a realistic basis for determining what type of organizational processes are addressed and which one is more appropriate and performance to improve them. Of course, Lean Six Sigma appearance changed the fragile balance of competition between the two methodologies in favor of the new competitor and on this basis we want to establish the real benefits of merging the two methodologies.

In this spirit, this research can be useful for organizations willing to optimize their work and being confronted with the problem of choosing the most appropriate methodology, but also researchers to broaden their knowledge horizon.

As far as the research methodology is concerned the paper is based on specialized literature documentation, i.e. books, articles, proceedings papers from different accessed databases, such as Emerald, Scopus, Elsevier, Google Scholar and Google Play Books.

3. DIFFERENCES BETWEEN LEAN AND SIX SIGMA

Lean and Six Sigma are methodologies aimed at increasing long-term profitability of the organization, hence the success of their meeting under the common umbrella of Lean Six Sigma. Lean is focused on the production flow and has a qualitative approach. Lean's goal is to increase the process speed and to reduce non added value, using Lean principles. On the other hand Six Sigma is focused on specific problem in order to improve the process quality and its approach is quantitative. Six Sigma's goal is to reduce process variation that leads to defects by statistical tools using DMAIC methodology. Thus, Six Sigma is useful in the improvement of process bearing value added, while Lean is contributing to eliminate activities that do not add value to the product.

Arnheiter and Maleyeff (2005) stated that it is clear that lean management and Six Sigma were derived from two different points of view. Lean production was derived from the need to increase product flow velocity through the elimination of all non value-added activities. Six Sigma developed from the need to ensure final product quality by focusing on obtaining very high conformance at the OFD level. The extended idea is resumed by Antony and Kumar (2011) in figure 1 showing fundamental differences between Lean and Six Sigma approaches.

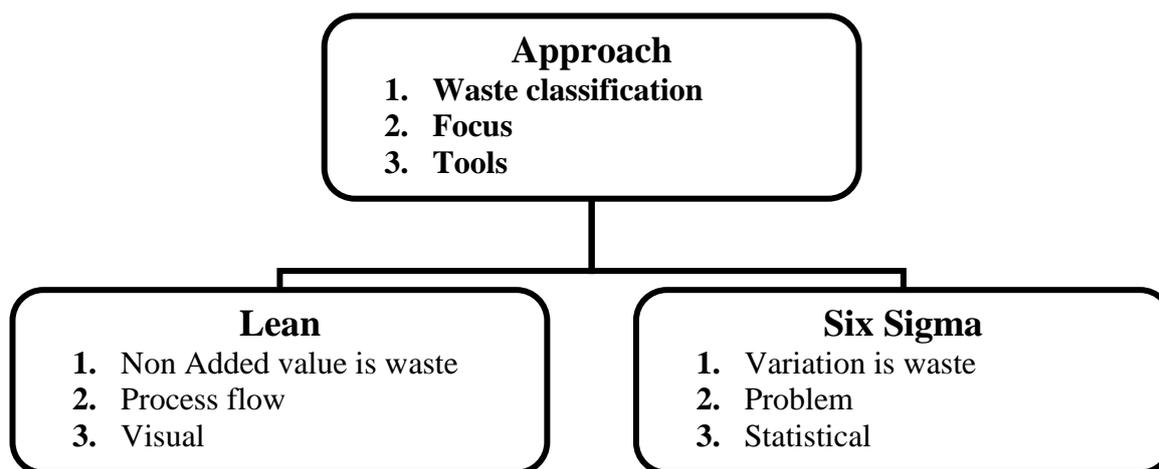


Figure 1. Key differences between Lean and Six Sigma Approaches

Source: adapted from Antony and Kumar (2011)

Also Su, Chiang and Chang (2006) analyzed the benefits and challenges between Lean and Six Sigma highlighting some differences between methodologies, as shown in table 1.

Table 1. The benefits and challenges for Six Sigma and Lean

Methodology	Six Sigma	Lean
Benefits	Uniform process output	Cycle time reduction
	Defect reduction	Work in progress reduction
	Cost reduction	Cost reduction
	Productivity improvement	Productivity improvement
	Culture change	Shorten delivery time
	Customer satisfaction	Space saving
	Market share growth	Less equipment needed
	Product/service development	Less human effort
Challenges	System interaction is not considered because processes are improved independently	Statistical or system analysis not valued
	Lack of specific speed tools	Process incapability and instability
	Long project duration	People issues

Source: adapted from Su, Chiang and Chang (2006)

Using specific tools to Lean or Six Sigma is also a selection problem. According to Snee (2010) in cases when shifting the process average or reducing process variation is appropriate for the problem at hand, Six Sigma will dominate. In cases when improving process flow or reducing process complexity is appropriate, lean tools may dominate.

Based on his studies and equally on studies made by Kumar and Dahlggaard some important and critical differences between Lean and Six Sigma are underlined by Antony and Kumar (2012), as seen in table 2.

Table 2. Fundamental and critical differences between Lean and Six Sigma

No.	Lean	Six Sigma
1.	Good for quick and initial round of improvements	Suitable for long-term and complex problems
2.	Requires low investment due to the nature of the training and the skills to be developed	Demands high investment and is not suitable for fixing common sense problems
3.	Has less emphasis on statistical tools and techniques	Requires the use of applied statistical methods for understanding and reducing variation
4.	No formal organizational infrastructure for implementation and deployment	Well defined organizational infrastructure (yellow belts, green belts, black belts, master black belts, deployment champions and sponsors)
5.	Looks into mapping of end to end process and uses value stream exercises to understand interactions between processes	System interaction between processes is not considered in a typical problem solving scenario

Source: adapted from Antony and Kumar (2012)

Wedgwood (2006) emphasize that Lean and Six Sigma focus on different elements of a process. In simple terms, Lean looks at what we shouldn't be doing and aims to remove it; Six Sigma looks at what we should be doing and aims to get it right the first time and every time, for all time. The differences between Lean and Six Sigma have also been underlined by Salaj, Rahim and Carretero (2010): definition, complexity, focus, technique, how they are viewed, what they are criticized for, scope, identification of gaps, view of inventory and production, practices (DMAIC vs Value Stream Map), cost of poor quality vs waste types, cost of poor quality vs waste percentages, execution, analysis vs action, tools, software, rewards, training (cost and material), change leadership and obstacles, project duration, project selection, financial savings, time to see results, link to suppliers, culture, measures, nature of problem level, shortcomings or desirable characteristics and results.

Fundamental differences between Lean and Six Sigma approaches to process management and improvement, as underlined by Antony (2011), are the following ones:

- Application of Six Sigma methodology requires more intense training compared to Lean methodology;
- Six Sigma implementation requires more investment as opposed to Lean implementation;
- Lean is fundamentally used to tackle process inefficiency issues whereas Six Sigma is primarily used to tackle process effectiveness issues;
- Six Sigma will eliminate defects in processes, but it will not address the question of how to optimise process flow. In contrast, lean principles are not very helpful in achieving high capability and high stability processes.

4. LEAN AND SIX SIGMA COMMONALITIES

According to George (2002) companies using the integrated approach of Lean and Six Sigma will gain four major benefits, such as become faster and more responsive to customers, strive for Six Sigma capability level, operate at lowest costs of poor quality and achieve greater flexibility throughout the business. An integrated approach to process improvement using lean

manufacturing and six-sigma principles is required, emphasize Cudney, Mehta and Monroe (2006), since both lean manufacturing and six-sigma are more of a cultural change meant to be the way a company does business rather than a one-time tool to be used for quick improvement.

For Hoerl and Gardner (2010) combining Six Sigma and lean as an Lean Six Sigma initiative enables organizations to benefit from both types of improvement, depending on the nature of the problem. Adding a serious DFSS initiative to the mix adds the ability to improve entitlement by designing new products, services, and processes. These form a powerful improvement combination.

Devane (2004) points out the same idea of combining methodologies instead of selecting one over the other: increased speed of implementation, more improvement projects can occur simultaneously, thus increasing profits faster, less time and energy on the part of senior management, swifter and more effective adaptation to external events and greater sustainability of huge improvements.

Even from the beginning, according to Antony and Kumar (2011), Lean Six Sigma has developed and broadened its range of appeal both globally and by industry sector. Its ability to reduce costs, improve quality and reduce customer delivery time has sealed its place as a leading methodology for improvement of our businesses in the past, present and hopefully the future.

Antony and Kumar (2012) emphasize commonalities between methodologies: both are continuous business process improvement methodologies, both focus on business needs defined by the customer, both involve a comprehensive toolkit for tackling process related problems. The synergy between Lean and Six Sigma was early mentioned by Pyzdek (2000). This synergy highlighted by Pyzdek is presented in table 3, which specifies for each significant Lean issue the contribution brought by Six Sigma.

Table 3. The Synergy of Six Sigma and Lean Production

No.	Lean	Six Sigma Contribution
1.	Establish a methodology for improvement	Policy deployment methodology
2.	Focus on customer value stream	Customer requirements measurement, cross-functional management
3.	Use a project-based implementation	Project management skills
4.	Understand current conditions	Knowledge discovery
5.	Collect product and production data	Data collection and analysis tools
6.	Document current layout and flow	Process mapping and flowcharting
7.	Time the process	Data collection tools and techniques, SPC
8.	Calculate process capacity and Takt time	Data collection tools and techniques, SPC
9.	Create standard work combination sheets	Process control planning
10.	Evaluate the options	Cause-and-effect, FMEA
11.	Plan new layouts	Team skills, project management
12.	Test to confirm improvement	Statistical methods for valid comparison
13.	Reduce cycle times, product defects, changeover time, equipment failures	Seven management tools, seven quality control tools, design of experiments

Source: adapted from Pyzdek (2000)

Same idea of merging the two methodologies is underlined by Chiarini (2011): combining the speed introduced by Lean and the Six Sigma capability of reducing variation, Lean Six Sigma seems to be a well-established system as confirmed by several authors.

Salaj, Rahim and Carretero (2010) pointed out that there are many areas where Six Sigma and lean share common grounds in terms of: the origin or development, principles or concepts, objectives or applications, leadership roles, staff roles and features or project management approach. Furthermore, even in the dimensions where they are different, there are still lots of similarities such as in the focus on customer satisfaction. Also, there are many compatible areas where one of them may excel forming an opportunity to help the other one. Thus, the integration of the two is possible and beneficial.

According to Antony (2011) some of the similarities between the Lean and Six Sigma approaches to process management are the following:

- Both are process focused or process-centric;
- Both need management support for success, especially in terms of creating the infrastructure and allocation of required budget and time for changing the culture of the business;
- Both can be used in non-manufacturing environments;
- Both methodologies are focused on business needs as defined by the customer;
- Both concepts use multi-disciplinary teams to address business problems;
- Both offer complementary tool sets which, together with each other and with other best management practices, offer a comprehensive means of transforming a business from operational chaos at one extreme to operational excellence at the other.

In relation with tools used either by Six Sigma or Lean, the tools used by both methodologies are presented in figure 1, adapted after Drohomerecki et al. (2014). However Lean Six Sigma is based on tools specific to both methodologies, which have to be used according to the process necessities.

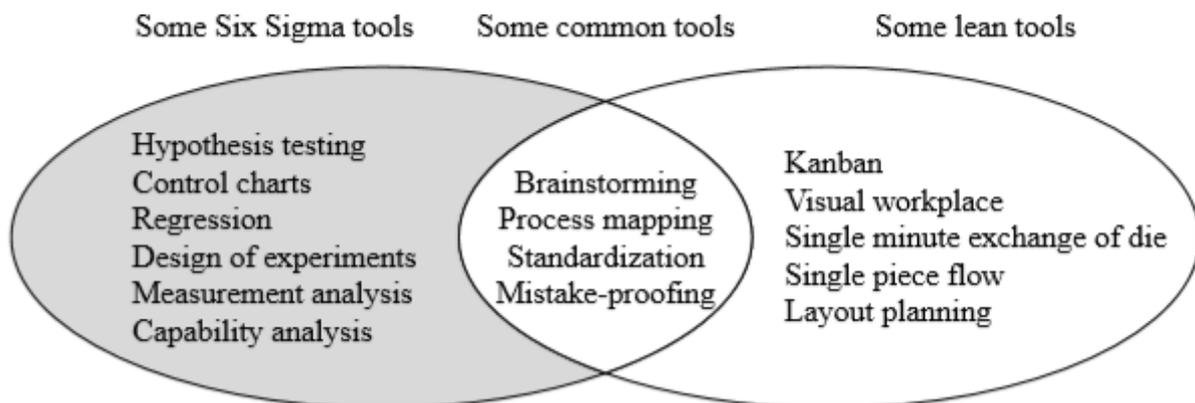


Figure 1. Six Sigma and Lean common tools
 Source: adapted from Drohomerecki et al. (2014)

Pyzdek (2003) underlined also the common points as both Six Sigma and Lean address the problem of muda, there is a great deal of overlap. It's not a choice of Six Sigma or Lean, it's Six Sigma and Lean. Based on standards of American Society of Quality, Salaj, Rahim and Carretero (2010) fitted Lean tools into Six Sigma's DMAIC frame, as shown in table 4.

Table 4. Lean methodology understanding as part of the Six Sigma black belt body of knowledge

Six Sigma project phase	Applicable lean tool or training topic
Define	Lean; Lean applications; Business processes and systems
Measure	Map the current state value stream to identify waste
Analyse	Creating a lean future state value stream map and analyze waste
Improve	Eliminate waste; reduce cycle time; use Kaizen and Kaizen Blitz
Control	Visual controls; Total productive maintenance

Source: adapted from Salaj, Rahim and Carretero (2010)

5. LEAN SIX SIGMA COMPARED TO LEAN AND SIX SIGMA

Merging in Lean and Six Sigma, Lean Six Sigma is based both on the strengths specific to each methodology and the strengths common to Lean and Six Sigma. Sunder (2013) underlined the advantages of Lean Six Sigma methodology over the other process improvement methodologies, i.e. Lean and Six Sigma:

- Structured approach to eliminate the root cause of the problem;
- Stakeholder involvement at every stage of the road map;
- Statistical as well as walk-the-floor approach combination;
- Breakthrough and sustainable improvements for customer delight;
- Improves teamwork and involvement;
- Easy to document and share for best practices;
- Cuts across cross-functional barriers;
- Reduces handoffs and improves process flow;
- Reduces both process waste and process variation;
- Systematic deployment approach.

Lean Six Sigma's power is based both on the strengths specific to Lean and Six Sigma, but also on the common strong points of methodologies. According to Maleyeff (2007) it is clear that Lean and Six Sigma encompass many common features, such as an emphasis on customer satisfaction, a culture of continuous improvement, the search for root causes, and comprehensive employee involvement. Antony, Escamilla and Cain (2003) highlighted that the application of Six Sigma principles combined with the speed and agility of lean strategy will produce solutions in the never ending quest for better, faster, cheaper business processes.

According to Snee (2010) Lean Six Sigma works better than previous approaches because it integrates the human and process aspects of process improvement. Human issues are bottom line focus, management leadership, sense of urgency, customer focus, project teams, culture change, while process issues are process improvement, analysis of variation, disciplined approach, quantitative measures, statistical thinking & methods and process management. In addition to the above mentioned benefits, according to Salaj, Rahim and Carretero (2010), Lean Six Sigma encourages the use of a common vision and language. Furthermore, each methodology is more suitable for certain levels and types of problems. That is why the integration of the two methodologies is important and saves a lot of effort and repetition.

Based on Lean and Six Sigma synergy, continuous business process improvement methodologies, Lean Six Sigma has developed as a powerful tool for solving process connected problems.

Despite the significant differences between Lean and Six Sigma, mainly related to their different focus, process waste consideration, their different tools and methodologies, their fusion has created a better tool for increasing process flow speed and reducing process variation. Lean Six Sigma's power comes from powerful commonality of both methodologies, such as focus on the customer needs, improving process by eliminating waste and delivering value, sustaining the continuous efforts to ensure improvements.

Lean Six Sigma is based on strengths specific to each of two proven to work methodologies and includes a comprehensive toolkit for process optimization, which may be used according to specific process requirements. Lean Six Sigma has combined Lean transformation tools used for right delivery with Six Sigma tools for increasing product quality and obtaining predictable results. In this manner optimized processes are characterized by minimum cycle time and waste, reduced inventory, better quality, maximum flexibility, better process reliability and a quick response to change.

Table 5 presents Lean Six Sigma approach to treat differences between Lean and Six Sigma and table 6 includes Lean Six Sigma approach for methodologies' commonalities.

Concerning Lean Six Sigma approach to treat differences between methodologies we basically noticed Lean Six Sigma' way for:

- methodologies' different goals;
- methodologies' different focus;
- specific process approach;
- different focus on process improvement;
- different main effect of methodologies;
- different associated effect of methodologies;
- different means of addressing the problem;
- different manner of tracking process stability;
- different manner of monitoring process improvements;
- specific process improvements;
- different process performance.

The analysis of table 5 reveals that, in cases when Lean and Six Sigma have different approaches, Lean Six Sigma gets either Lean's approach or Six Sigma's approach, in order to preserve the power of the two methodologies.

This flexibility, as well as choosing the best manner for treating process related problems, explains the success of process optimization using Lean Six Sigma.

Table 5. Lean Six Sigma approach versus Lean and Six Sigma approaches

No.	Lean Six Sigma approach to treat differences between Lean and Six Sigma	Origin	Lean	Six Sigma	Lean Six Sigma
1	Reduce waste and increase process speed	Lean	Y	N	Y
2	Reduce process variation and improve critical to quality	Six Sigma	N	Y	Y
3	Focus on customer value stream	Lean	Y	N	Y
4	Focus on process defects' elimination	Six Sigma	N	Y	Y
5	Qualitative approach of optimization through non value-added activities elimination	Lean	Y	N	Y
6	Quantitative approach of optimization through improved process capability	Six Sigma	N	Y	Y
7	Make value flow at the pull of customer	Lean	Y	N	Y
8	Improvements using statistic tools & techniques	Six Sigma	N	Y	Y
9	Main effect on cycle time reduction	Lean	Y	N	Y
10	Main effect on reducing defect numbers	Six Sigma	N	Y	Y
11	Associated effects for reducing work in progress inventory	Lean	Y	N	Y
12	Associated effects for improving products quality	Six Sigma	N	Y	Y
13	Focusing on descriptive displays and workplace visual management	Lean	Y	N	Y
14	Focusing on the application of structured and rigorous data driven methodology	Six Sigma	N	Y	Y
15	Using standardized process worksheet and procedures	Lean	Y	N	Y
16	Tracking process stability and planning controls to sustain improvements	Six Sigma	N	Y	Y
17	Tracking process improvements using tests to confirm results	Lean	Y	N	Y
18	Monitoring and control of process improvements to maintain quality through statistical methods	Six Sigma	N	Y	Y
19	Rapid incremental improvements	Lean	Y	N	Y
20	Breakthrough improvements with large impact on organization's performance	Six Sigma	N	Y	Y
21	Robust performance for right delivery	Lean	Y	N	Y
22	Predictible results for right quality	Six Sigma	N	Y	Y

Source : Author

Concerning Lean Six Sigma approach in case of methodologies' commonalities we remarked:

- common tools;
- common focus on business needs;
- process improvement;

- process optimization;
- engagement of company management;
- engagement of company employees;
- improvement of customer service;
- practical continuous process improvement methodologies with proven effective practice.

Table 6. Lean Six Sigma approach for methodologies' commonalities

No .	Lean Six Sigma approach for Lean and Six Sigma commonalities	Origin	Lean	Six Sigma	Lean Six Sigma
1	Common tools: Process Map, 5 Whys/2 Hows, Pareto diagram, Fishbone diagram	Common	Y	Y	Y
2	Focus on business needs according to the customer	Common	Y	Y	Y
3	Continuous process improvement methodologies	Common	Y	Y	Y
4	Improvement of product/service quality	Common	Y	Y	Y
5	Improvement of customer satisfaction	Common	Y	Y	Y
6	Reducing costs	Common	Y	Y	Y
7	Optimizing process development and productivity growth	Common	Y	Y	Y
8	Engage company management in improving; management must be committed, involved and supporting improvements	Common	Y	Y	Y
9	Engage company employees in improving (problems identification and contribution to problem solving)	Common	Y	Y	Y
10	Improve customer service	Common	Y	Y	Y
11	Practical methods with proven effective practice	Common	Y	Y	Y

Source : Author

In which it concerns Lean Six Sigma approach for Lean and Six Sigma commonalities the previous table highlights the large number of common strengths of methodologies taken over by Lean Six Sigma, which achieve an important contribution to successful implementation of process optimization.

6. CONCLUSIONS

Lean Six Sigma is nowadays applied in many organizations in Romania and worldwide. For Romania, according to Munteanu (2017), continuing and enhancing the implementation framework of Lean Six Sigma, in spite the difficulties and specific implementation problems, is a "must", as is the only long term option for growth and competitiveness.

This paper tries to reveal the benefits brought to organizations by Lean Six Sigma compared to Lean and Six Sigma. As shown, for different process approach Lean Six Sigma has the flexibility to get the better one, preserving in this manner the power of both methodologies. Lean Six Sigma approach for commonalities is also to preserve common strengths of

methodologies and so choosing the best manner for treating processes Lean Six Sigma manages to achieve successful process optimization.

Meantime a successful implementation requires readiness for change as well as cultural change, such as think and work differently, make decisions based on data and understanding the need for change as a progress condition. It is very important to point out that project selection and prioritization is also fundamental to maximize their chances of success. Total commitment and support by organization management, training, linking Lean Six Sigma to business strategy, customers and suppliers could also be mentioned among critical success factors for implementation.

Providing a world class business strategy, Lean Six Sigma requires organizational change, leadership and employees commitment, promotes successful teamwork and combines aggressive goals with a powerful methodology. Lean Six Sigma produces knowledge for eliminating defects, shorter cycle time, better productivity, reducing costs and increased competitiveness. Finally Lean Six Sigma strengthens the organization's market position. This paper should be considered as a plea and a support for using Lean Six Sigma in Romania and worldwide.

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