Systematic Literature Review: The Relationship between Lean Six Sigma and Sustainability

Sambudi Hamali, Diza Iwari, Nabilah Anindya Putri
Management Department, BINUS Business School Undergraduate Program, Bina Nusantara University, Jl. K.H. Syahdan No. 9, Palmerah, Jakarta 11480, Indonesia
sambudi_hamali@binus.ac.id, iwaridiza@gmail.com, nabilahanindyap@gmail.com

Abstract
The purpose of this study is to determine the relationship between Lean Six Sigma and Sustainability and to know the approaches and tools used by different industrial sectors. The method used in this study is a Systematic Literature Review. The data analysis method used in this study was the Perish 7 application and choose the Scopus Search option. The results of this study show that Lean Six Sigma has a positive impact on Sustainability in various industrial sectors by using the DMAIC approach, DMAIC + Transparency and Accountability (DMAIC Modify) and VSM-DMAIC, as well as the recommended tools in each phase and Industry.

Keywords
Lean Six Sigma, Sustainability, DMAIC

1. Introduction
To face the increasing competition in the global market, the need for higher production efficiency, and lower operating costs to achieve good performance and competitiveness, companies must seek innovative business methods. Due to technological advances, environmental and social issues that are being considered today, companies are forced to focus on the sustainability of operations management. (Magon et al., 2018). Sustainability is directly related to three pillars: environment, social, and economy (Cherrafi et al., 2017). One of the most complex problems facing organizations today is how to achieve success through strategies in support of environmental and social sustainability, but efforts to improve this have been seen as an obstacle to economic sustainability in organizations (Zhong & Wu, 2015). However, recently many businesses have found that these efforts result in reduced operating costs and increased employee satisfaction (Resta, Dotti, Gaiardelli & Boffelli, 2016).

The use of management systems to solve global sustainability challenges has now been explored (Tasdemir & Gazo, 2018). Sustainability has been implemented through various systems related to environmental management, health and safety management, and social responsibility management (Nunhes, Motta & Oliveira, 2016). In this context, Lean Six Sigma as a management system that can achieve the expected results for organizational sustainability through continuous improvement methodologies. (Antony, Gupta, Sunder & Gijo, 2018). Lean Six Sigma is a business strategy and methodology that improves performance processes by having the skills, techniques and tools to find sustainable solutions to reduce waste, optimize resources, and increase process efficiency (Lu, Laux & Antony, 2017). The success of Lean Six Sigma as one of the most popular methods of continuous improvement has led many companies around the world to implement it, to tackle their operations and become more competitive (Antony, Snee & Hoerl, 2017). The methodology used by Lean Six Sigma to solve a problem includes five phases called the DMAIC cycle (Define, Measure, Analyze, Improve, and Control) (Patel et al., 2019). Many studies have explored the relation between Lean Six Sigma and Sustainability, but there is an inconsistency in these studies regarding the relation between Lean Six Sigma and Sustainability from different industrial sectors, also the approaches and tools used to apply the Lean Six Sigma methodology. Therefore, due to the lack of knowledge of the relation between Lean Six Sigma and Sustainability, the authors conducted a Systematic Literature Review to determine this relation, then presented various approaches and tools that have been used to apply the Lean Six Sigma methodology. This research relies on journal references for the past 13 years from 2008 to 2020, with the reason that this topic just appeared and discussed in 2008, then further research has been conducted to date.

From the discussion of the Lean Six Sigma and Sustainability described above, there are several questions related to research or systematic literature review, which is how the relation between Lean Six Sigma and Sustainability of different industrial sectors, and what approaches and tools are used to apply the Lean Six Sigma method.

1.1. Objectives

The purpose of this study is:

1. To find out the relation between Lean Six Sigma and Sustainability from different industrial sectors.
2. To find out which approaches, and tools are used to apply the Lean Six Sigma method.

2. Research Methodology

The method used in this study is a Systematic Literature Review. According to Campbell Collaboration (2016), the Systematic Literature Review application consists of six steps:

1. Related research questions are defined by developing a preliminary theoretical framework for the phenomenon under study.
2. Determine the primary study's essential characteristics related to inclusion, exclusion criteria for the craft and/or, for example, research methods, study focus, outlet, and language use.
3. A sampling of relevant literature related to identifying search methods, such as database searches and references, and determining keywords for the initial sample.
4. Select the literature concerned with the application of inclusion-exclusion criteria and/or.
5. Synthesizing related literature is concerned with applying coding schemes to extracting related information from literature and synthesizing studies by summarizing, integrating, or aggregating different findings across significant studies.
6. Reporting results relate to reporting results from reviews and provides an overview of literature reviews and findings from thematic discussions.

3. Literature Review Protocol

3.1. Keyword Search Literature

For literature search criteria, the author uses terms related to "Lean Six Sigma" AND "Sustainability" using the Perish 7 application and selects the Scopus Search option.

3.2. Literature Search Sources

The source of the literature search database that the author uses is Scopus Search through the Perish 7 application. Selecting this application can make it easier for authors to find journals. Authors can limit the years of searching to produce journals with the desired year of publication.

3.3. Literature Inclusiveness Criteria

The author's literature criterion is the publication of the last 13 years from 2008 to 2020. Discusses Lean Operation and Six Sigma, which refer to the keywords Lean Six Sigma and Sustainability contain empirical research and case study by direct research, aiming for the data obtained to be real and correct. The authors chose the upper limit for the publication year of 2008 because that year was the first-time articles related to the topic and research objectives were published.

3.4. Literature Search and Selection Process

The process of searching for journals using the Perish 7 application and selecting the Scopus Search option. There were 89 articles with the keywords Lean Six Sigma and Sustainability. Furthermore, it is analyzed and evaluated with the result is up to 16 articles that match the specified objectives. The analysis and evaluation are carried out by each article's objectives, year of publication, methods, problems, keywords, and conclusions.

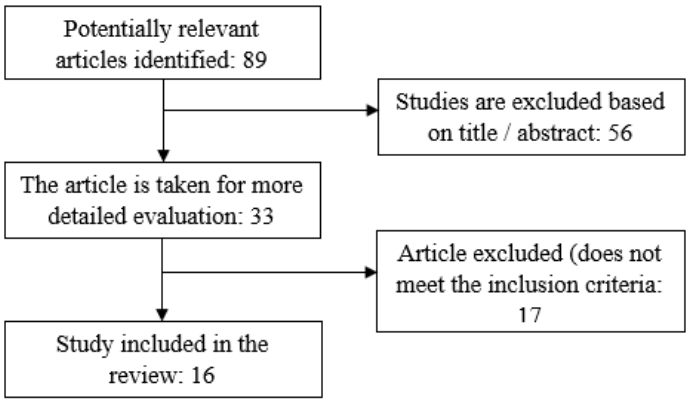

Figure 1. SLR Research Process

3.5. Mapping Process and Literature Analysis

Mapping and analysis were carried out using Excel tables. These articles are grouped based on Author, Title, Year, Source, Publisher, Correlation, Tools, Author Background, Research Model, and Industry to facilitate the analysis and evaluation process to determine and sort articles according to the purpose of this study.

4. Results and Discussion

4.1 Descriptive Analysis

This study analyzes the distribution of publications per year over the studied period to look at trends in research over the years. The search results obtained a total of 16 relevant articles regarding the quality of the data.

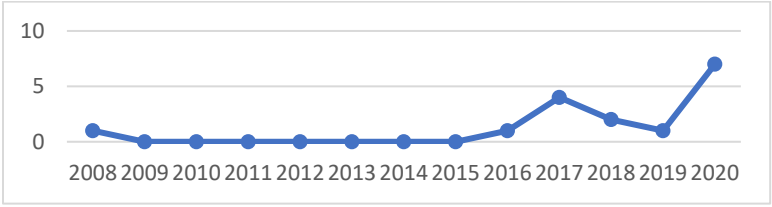

Figure 2. Distribution of Publications over Time

Based on the Figure 2 above, the graph of the growth in the number of articles from 2008 to 2020, which is in 2008 has a percentage of 6.25% or just one journal. From 2009 to 2015, research on the relation of Lean Six Sigma to Sustainability was rarely known and understood by various people, because efforts to improve Environmental and Social Sustainability required high costs that making it an obstacle to Economic Sustainability. Therefore, around this year there are no journals related to research themes. However, in 2016 and beyond, several businesses have proven that these efforts to improve Environmental and Social Sustainability result in reduced Operating Costs, and increased employee satisfaction. (Cherrafi et al., 2016)

In 2016, the number of journals increased compared to the previous year, which has one journal entitled "Lean Six Sigma Sustainability framework: A case study on an automotive company" (Kowang, Yong, Rasli and Long, 2016). In 2017, the increased number of selected journals was quite significant, which has four journals. In the following years, 2018 to 2019, the number of journals corresponding to the research topic has decreased, respectively by two and one journal. In the following year, 2020 was peaked with contributing a percentage of 43.75% of the total.

4.2. Descriptive Analysis of Literature based on Publication Journal

This study performed a distribution analysis based on the type of publication journals studied in articles related to Lean Six Sigma's Relation with Sustainability to see who had the most influence on related topics from 2008 to 2020.

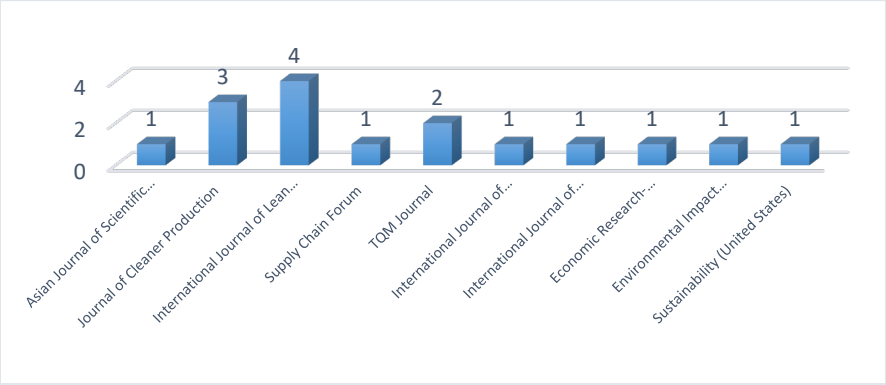

Figure 3. Distribution of Publication by Type of Article

Based on the Figure 3 above, the type of article that is most commonly found is in the International Journal of Lean Six Sigma with a percentage of 25% which equal four articles, the second place is the Journal of Cleaner Production with a percentage of 18.75%, which is three articles, the third place is in publication TQM Journal with two journals, and apart from the three journals, it has the same number of publications, which is one journal.

4.3. Descriptive Analysis of Literature based on Articles Research Model

The search results for articles from 2008 to 2020 that focused on Lean Six Sigma's Relation with Sustainability had some differences at the article research model level.

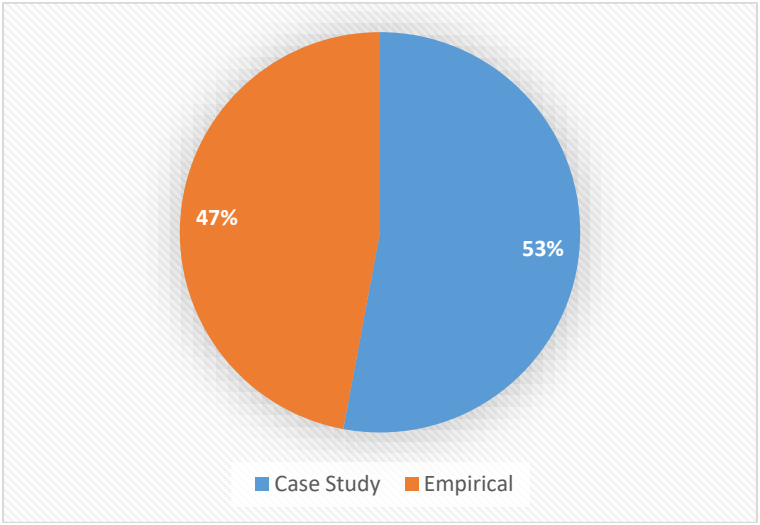

Figure 4. Percentage of Publication based on Article Model

Based on the Figure 4 above, the research in this case is interested in examining the article model with Case Study and also Empirical because the article model has been done in previous research. Of the total 16 articles, the empirical article model was 47%, and the case study article model was 53%. It can be concluded that the most common article model is the case study article model

4.4. Descriptive Analysis of Literature based on Author's Scientific Background

Based on the search results for articles from 2008 to 2020, here are some of the author's scientific backgrounds that form the basis of research focused on the relation between Lean Six Sigma and Sustainability.

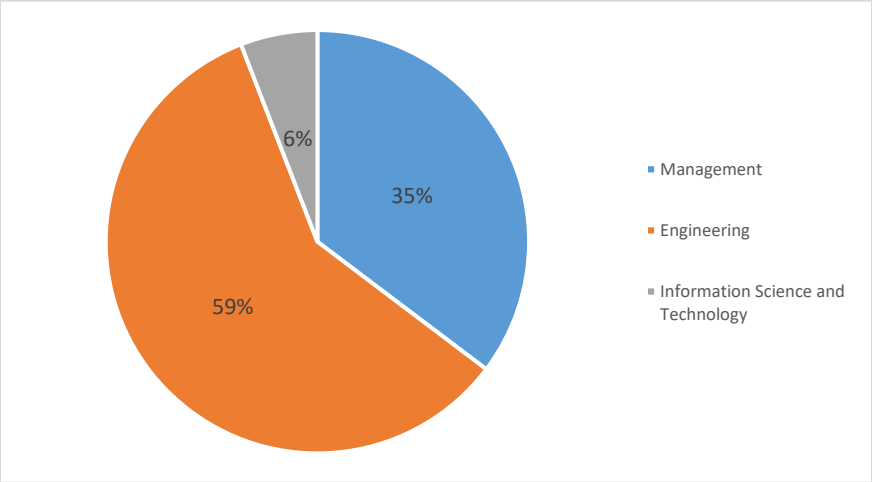

Figure 5 Percentage of Publication based on Author's Scientific Background

Based on the Figure 5 above, it was found three backgrounds out from a total of 16 articles that concern, which is the background in Engineering with the highest percentage of 59%, Management with a percentage of 35%, and Information Science and Technology with the lowest percentage of the others which is 6%.

4.5. The Relationship between Lean Six Sigma and Sustainability from different Industry Sectors

1. Service Industry

a) Governance

A method based on the Lean Six Sigma program is recommended for achieving sustainability governance, as it systematically rearranges the way organization works to identify and minimize waste of unnecessary steps. The presence of a Critical Successful Factor (CSF) in the application of LSS which has a positive impact on Sustainability Governance. (Table 1)

Table 1. Critical Successful Factor (CSF) Lean Six Sigma in Sustainability Governance

CSF *Lean Six Sigma* pada *Sustainability Governance*
1. Eliminate Negligence, Waste, or Willful Misconduct.
2. Transparency in City Operations
3. Accountability of Government

Source: Rowland (2008)

b) Construction

Development of a Knowledge-Based (KB) Management System that integrates Lean Six Sigma as an advanced quality philosophy for Sustainable Building Maintenance (SBM) into international best practice (Aldari, Khan, Hernandez, 2017). The used of Gauge Absence Prerequisites (GAP) Technique in KB-Lean6 for Sustainable Building Maintenance, it can identify weaknesses and strengths in practice and provide a quantitative basis for the system effectively, with implementation results such as easier diagnosis and repair of system errors, reduced lead- time is achieved, and increase financial goals such as a proportionate reduction in electricity demand, so

that it can be stated that the Lean Six Sigma relation has a positive impact on Sustainability Maintenance in the Construction sector.

c) Healthcare

The integration of Lean Six Sigma has resulted in reduced time waste and lead-time by considering patient needs, minimizing errors and costs, improving the quality of care, increasing staff engagement, and continuous improvement in patient satisfaction (Zhu, Johnson, Sarkis, 2018). In addition, it can improve patient safety, improve patient care, and reduce medication errors (Trakulsunti et al., 2020). The application of Lean Six Sigma can overcome several cases in the Healthcare sector, (Table 2) so it can be concluded that Lean Six Sigma has a positive impact on sustainability. Below are the phases of the Lean Six Sigma Sustainability Roadmap that can reduce Medication Errors: (Table 2)

Phase 1: Readiness factors for implementing LSS to reduce medication errors.
Phase 2: Preparation, Initialization and Implementation (using DMAIC);
Phase 3: Sustainability

Table 2. Impact of Lean Six Sigma for Sustainability in Hospital Cases

No	Case in Hospital	Lean Six Sigma Benefit
1	*Linen Operations in Hospitals*	can optimize the linen distribution system (bed sheets) to make it more responsive, reliable and standardized
2	*Medication Delivery System in Hospitals*	achieving the effectiveness of the drug delivery system and the potential environmental impact on the drug supply chain in hospitals.
3	*Sterile Processing in Hospital*	reduce breakdown rates and inventory control costs for operating instruments.

Source: Zhu, Johnson, Sarkis (2018)

d) KPO/BPO (Knowledge Process Outsorcing/Business Process Outsorcing)

The application of the Lean Six Sigma method in KPO / BPO (Knowledge Process Outsourcing / Business Process Outsourcing) can have a positive impact on operational performance which is part of the way a company maintains sustainability, as a study on Motiani & Kulkarni (2019) shows the impact on Costs which creates 5% -25% of Productivity Improvement, an impact on Speed which creates time savings of up to 20% -80%, and an impact on Quality which can reduce product defects by a percentage of 15% -125%.

Table 3. Influence of Lean Six Sigma with Sustainability in KPO/BPO Services

Criteria on Operational Performance for Sustainability	Influence from LSS Implementation			
	C1	C2	C3	C4
Cost (Productivity Improvement, Cost Reduction)	+	+	+	+
Speed (Time reduced, Improved Time)	+	+	++	+
Quality (Improved resolution, Reduced defect)	+	+	++	+

Source: Motiani & Kulkarni (2019)

In the Table 3 above, companies are categorized by the term C1 for IT Support, C2 for Transportation Service, C3 for Outsourcing Service, and C4 for Bank & Financial Service. In each company column, it displayed for the results of synergy (+ moderate, ++ strong), conflict (- moderate, - strong), or (0 has no influence), with a percentage (0% -50%, for moderate, and >50% for strong). There are several actions taken to maintain sustainability in the KPO / BPO Service Industry, such as (1) Maturity Assessment, which is a way for the team to improve the implementation and effectiveness of Lean Six Sigma practices, (2) Review the progress of Lean Six Sigma implementation by Senior Management (LSS Implementation Dashboard), and (3) Annual Benefit Tracking, which is tracking benefits for the implemented improvement project.

2. Manufacturing Industry

a) Automotive

Kowang, Yong, Rasli & Long (2016) defined a Critical Successful Factor in research of Automotive companies that have been implementing Lean Six Sigma for 15 years and have a positive impact on sustainability in the company. The following is the Critical Successful Factor (CSF) which forms the basis for the relation between Lean Six Sigma and Sustainability has a positive impact. (Table 4)

Table 4. Critical Successful Factor (CSF) Lean Six Sigma in Sustainability Automotive

CSF Lean Six Sigma in Sustainability Automotive Industry
1. Continuous Improvement (CI) Culture
2. Innovative Culture
3. Management Team's Approach
4. Employee LSS Knowledge
5. Communication

Source: Kowang, Yong, Rasli & Long (2016)

There is literature that explains the Structural Measurement Model by evaluating the Critical Failure Factor (CFF) in the SLSS (Sustainability Lean Six Sigma) combination to overcome failures on implementing Lean Six Sigma. (Swarnakar, Tiwari & Singh, 2020) Table 5.

Table 5. Critical Failure Factor (CFF) Lean Six Sigma in Sustainability Automotive

CFF Lean Six Sigma in Sustainability Automotive Industry
1. Deficiency in organizational Top Management Involvement and Support
2. Deficiency in Structured SLSS Framework Implementation Training
3. Lack and Poor Utilization of Resources (Finance, Human, Technical, etc)
4. Poor SLSS experts selection strategy
5. Lack of Social, Environmental and Economic Thinking
6. Poor Organization Working Culture
7. Lack of "5s" Environment
8. Lack of "Kaizen" Environment
9. Ineffective time Management
10. Lack of Knowledge about SLSS Tools and technique
11. Poor production planning strategy
12. Deficiency in proper statistical and visual Control technique
13. Uncertainty and Competition
14. Lack of Motivation encouragement and reward
15. Lack of Structured Scheduling
16. Lack of modern Technology used for Manufacturing
17. Poor team management and lack of cross-functional
18. Inappropriate Communication System
19. Inappropriate inspection method of raw material
20. Lack of Structured Model/Sequential process of Implementation
21. Deficiency in the estimation of SLSS Framework implementation Cost and their benefits
22. Deficiency in consideration of Human Factors
23. Use of inappropriate performance Measurement system
24. Deficiency in clear vision and future plan
25. Lack of right SLSS Project prioritization and deployment
26. Poor treatment of organization waste

Source: Swarnakar, Tiwari & Singh (2020)

According to Ruben (2020) there are seven constructs used as Structural Models that have been tested for validity using SEM Software to prove that there is a strong correlation and positive relation between Lean Six Sigma and

Sustainability, which is (1) Employee Management, (2) Defect and waste management, (3) Business Strategy, (4) Safety Aspects, (5) Environmental Performance, (6) Economic Performance, and (7) Organizational Performance.

b) Food

The application of the Lean Six Sigma method can get benefits and achievement of sustainability in the Food sector, because it focuses on value-added activities, improves process performance and contributes to greater environmental sustainability (Powell, Lundeby, Chabada, Dreyer, 2017). Tables 6 & 7

Table 6. Critical Successful Factor (CSF) Lean Six Sigma in Sustainability Food Industry

CSF Lean Six Sigma in Sustainability Food Industry
1. Management Commitment
2. Measuring, root-cause analysis, discussions, communication and awareness
3. Representatives from all parts of the production

Source: Powell, Lundeby, Chabada & Dreyer (2017)

Table 7. Key Management for Lean Six Sigma Implementation

Key Management for Lean Six Sigma Implementation in Food Industry
1. Leadership and People
2. Lean Six Sigma Tools,
3. Continuous Process Improvement,
4. Strategic Planning,
5. Stakeholders,
6. Results and Knowledge Management.

Source: Cherrafi et al., (2017)

c) Packing

The application of the Lean Six Sigma method in Scottish Packing Company determines Critical Success Factors (CSF) as an important variable to achieve an effective and successful Lean Six Sigma implementation that has a positive impact on sustainability in the company. (Vallejo & Antony, 2020) Table 8

Table 8. Critical Successful Factor (CSF) Lean Six Sigma in Sustainability Packing

CSF Lean Six Sigma in Sustainability Packing Company
1. Top Management Commitment, Leadership and Engagement,
2. Recognition of The Need for Change,
3. Effective Training,
4. Recognition and Reward System to Motivate Employees.
5. The Connection between The Business Strategy and The CI Initiative.

Source: Vallejo & Antony (2020)

d) Hard-Disc Drive

The application of Lean Six Sigma method through DMAIC-based approach to systematize Sustainable-VSM (Sus-VSM) in the Hard-Disc Drive sector can overcome deficiencies in Sus-VSM by offering continuous improvement processes, such as for waste reduction, observing improvements in operational performance and failure rates lower, so it has a positive impact on Sustainability in the Hard-Disc Drive sector. (Jamil et al., 2020)

e) Electric Component

The Fuzzy Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique is applied to evaluate the enablers of implementing Lean Six Sigma which has a positive impact on sustainability in Electric Component sector (Parmar & Desai, 2020). The relation between the enablers will help managers to develop effective strategies and policies for the successful implementation of Sustainability Lean Six Sigma (SLSS). Table 9.

Table 9. The most influence Enablers of SLSS Implementation

The Enablers of SLSS in Electric Component Industry :
1. The Support and Commitment of Top Management
2. Environmental Management System
3. Organizational Culture, Change, and Improvement
4. Market Increase
5. Organizational readiness to implement SLSS

Source: Parmar & Desai (2020)

Based on the final search results, there were 16 articles selected from 2008 to 2020, here are the summary results regarding the relationship between Lean Six Sigma and Sustainability from different industrial sectors which are presented in Table 10.

Table 10 The relation between Lean Six Sigma and Sustainability in different Industrial Sectors

Author and Years	Key Contribution	Industry	The Relationship Lean Six Sigma and Sustainability
M. Rowland (2008)	Creating sustainable city governance with the subject of natural resources, such as water and fossil fuels, and how these can be preserved for the future.	Service (Governance)	Positive
Tan Owee Kowang, Tan Su Yong, Amran Rasli, Choi Sang Long (2016)	Develop a conceptual framework for Sustainability Lean Six Sigma based on literature reviews and case studies of companies that have implemented Lean Six Sigma for 15 years.	Manufacturing (Automotive)	Positive
Jessica Galdino de Freitas, Helder Gomes Costa, Fernando Toledo Ferraz (2017)	Verifying how Lean Six Sigma (LSS) can affect organization sustainability through their projects as there are several scientific studies that attempt to evaluate the relation that exists between Lean, Six Sigma and Sustainability.	Manufacturing, Service	Positive
Daryl Powell, Sissel Lundeby, Lukas Chabada, Heidi Dreyer (2017)	Examining the application of Lean Six Sigma in the sustainability of the process industry, insights into the food processing industry, and evaluate the impact of Lean Six Sigma on environmental sustainability.	Manufacturing (Food)	Positive
Jasim Aldairi, M.K. Khan J, Eduardo Munive-Hernandez (2017)	Developing a Knowledge-Based (KB) system for the maintenance of Lean Six Sigma (LSS) in Sustainable Building Maintenance (Lean6-SBM).	Service (Construction)	Positive
Anass Cherrafi, Said Elfezazi, Kannan Govindan, Jose Arturo Garza-Reyes, Khalid Benhida & Ahmed Mokhlis (2017)	Presents a framework that methodically guides companies through a five-stage and sixteen-step process to effectively integrate and implement Green, Lean and Six Sigma approaches to improve Sustainability Performance.	Manufacturing (Food)	Positive
Nadiye O. Erdil, Can B. Aktas, Omid M. Arani (2018)	Develop a model framework to fully embed Sustainability into every Lean Six Sigma project that builds on current practices. The broad coverage of	Manufacturing, Service	Positive

	Lean Six Sigma, records of its effectiveness and overlaps		
Qingyun Zhu, Sharon Johnson & Joseph Sarkis (2018)	Discusses additional dimensions and mechanisms for integrating Lean and Green in the hospital environment, by proposing a system framework based on the traditional IDEF meta model which is literature reviews and published case studies.	Service (Healthcare)	Positive
Naresh Motiani, Abhay Kulkarni (2019)	• Knowledge of some important aspects of sustainability when implementing Lean Six Sigma in the KPO / BPO industry • Examine the impact of the Lean Six Sigma operations management model on the KPO / BPO industry	Service (KPO/BPO, Knowledge Process Outsorcing/ Business Process Outsorcing)	Positive
Veronica Flor Vallejo, Jiju Antony, Jacqueline Ann Douglas, Paul Alexander, Michael Sony (2020)	• Developing a practical, easy-to-use and accurate Lean Six Sigma roadmap for SMEs in Scotland • Determine the Critical Successful Factor (CSF) for the successful implementation of Lean Six Sigma and Sustainability	Manufacturing (Packing)	Positive
Ben Ruben R., S. Vinodh and Asokan P. (2020)	Describe the development of the Structural Measurement Model using the Structural Equation Modeling (SEM) technique to validate the existing relation between Lean Six Sigma (LSS) and sustainability in manufacturing	Manufacturing (Automotive)	Positive
Norhazrina Jamil, Hamed Gholami, Muhamad Zameri Mat Saman, Dalia Streimikiene, Safian Sharif & Norhayati Zakuan (2020)	• Propose a logical and well-defined approach using the DMAIC method to allow the industry conduct a systematic study of Sus-VSM • Presents the application of the DMAIC approach, to guide operations managers initiating improvement projects.	Manufacturing (Hard-Disc Drive)	Positive
Vikas Swarnakar, Anil Kr Tiwari and A.R. Singh (2020)	Identify, evaluate and develop a structured model to measure the relation between Critical Failure Factors (CFF) that affect the implementation of the Sustainable Lean Six Sigma (SLSS) Framework in the manufacturing industry.	Manufacturing (Automotive)	Positive
Pranay Sureshbhai Parmar, Tushar N. Desai (2020)	Identify and evaluate enablers of Sustainable Lean Six Sigma.	Manufacturing (Electric Component)	Positive
Mahender Singh Kaswan, Rajeev Rathi (2020)	• Integration of Green, Lean, and Six Sigma through common conceptual similarities and characteristics. • Create a Green Lean Six Sigma (GLSS) Framework and provide related tools at every stage of implementation. • Facilitation of the industry personnel for the gradual application of GLSS through a systematic understanding of GLSS.	Manufacturing, Service	Positive
Yaifa Trakulsunti, Jiju Antony, Jacqueline Ann Douglas (2020)	Describe the implementation of Lean Six Sigma and Sustainability Roadmap to guide Healthcare practitioners in reducing Medication Errors.	Service (Healthcare)	Positive

4.7. Approaches and Tools used for the application of the Lean Six Sigma Method

The approach applied to the Lean Six Sigma method, namely DMAIC (Define, Measure, Analyze, Improve and Control) approach is applied on Service industry in the sector of Construction, Healthcare, and KPO / BPO, and is also applied on Manufacturing industry in the sector of Automotive, Hard-disc Drive, Packing and Electric Component. Then, DMAIC + Transparency and Accountability (DMAIC Modify) approach is applied on Service industry in the Governance sector, and VSM-DMAIC approach is applied on the Manufacturing industry in the Food sector. Meanwhile, the tools used depend on each phase and the industry. The following is an explanation of the approach in general, as well as recommendations for the tools used to implement Lean Six Sigma in various industrial sectors are presented in Table 11 and Table 12.

a) Define
Define phase consists of clarifying the scope of project, identifying problems, and determining objectives.

b) Measure
Measure phase consists of establishing reliable / applicable metrics to monitor the characteristics of the main processes, the scope of the parameters considered, and their performance to understand their progress towards the goals set in the Define phase (Garza-Reyes, 2015).

c) Analyze
Analyze phase involves system analysis to identify ways to reduce the gap between current performance and desired goals (Garza-Reyes, 2015).

d) Improve
Improve phase describes the improvements of the value stream process can achieve by incorporating the waste elimination / minimization approach formulated in the previous phase.

e) Control
Control phase, it involves setting up a continuous monitoring mechanism and improving actions taken, ensuring that all employees carry out the improvement process uniformly.

f) Transparancy
Transparency phase of DMAIC + Transparency and Accountability (DMAIC Modify) approach on Governance sector, it aims to disseminate the citizens for all information about city public businesses, quasi-public entities, and copies of government contracts in a way that meets the requirements of Sustainability (Rowland, 2008).

g) Accountability
Accountability phase of DMAIC + Transparency and Accountability (DMAIC Modify) approach on Governance sector, it aims to create a system of rewards and sanctions for city government officials, employees and quasi-public entities in order to meet the requirements of Sustainability (Rowland, 2008).

h) VSM (Value Stream Mapping)
VSM (Value Stream Mapping) phase of VSM-DMAIC approach on Food sector, it aims to select project priorities and also to identify points in the process where material wastage occurs (Powell, Lundeby, Chabada, Dreyer, 2017).

Table 11. Approaches and Tools used for implementing Lean Six Sigma in Service Industry

Phase	**Industri *Service***			
	Construction	***Healthcare***	***KPO/BPO***	***Governance***
VSM (Value Stream Mapping)	-	-	-	-
Define	1. *Process Map* 2. *Critical to Quality (CTQ)* 3. *SIPOC* 4. *Project Charter*	1. *SIPOC* 2. *Process Map* 3. *Project Charter*	1. *Customer Journey Mapping* 2. *Value Stream Mapping (VSM)* 3. *Lateral Thinking* 4. *Agile Practice* 5. *Standard Work* 6. *Performance Management*	*Project Charter*
Measure	1. *Cause and Effect (C&E) Diagram/ Fishbone Diagram* 2. *Failure Mode and Effect Analysis (FMEA)* 3. *Value Stream Mapping (VSM)*	1. *Value Stream Mapping (VSM)* 2. *Data Collection and Analysis*	1. *Value Stream Mapping (VSM)* 2. *Project Prioritization* 3. *Risk Assessment* 4. *Cost Benefit Analysis* 5. *Upstream Waste Analysis* 6. *Client Relationship* 7. *Prototype Testing*	*Measurement System Analysis*
Analyze	1. *Pareto Chart* 2. *Cause and Effect (C&E) Diagram*	1. *Brainstorming* 2. *Cause and Effect (C&E) Diagram* 3. *Multi-voting* 4. *Root Cause Analysis (RCA)*	1. *Lean Management* 2. *Problem Solving* 3. *Standardization* 4. *Robotic Process Automation (RPA)* 5. *Machine Learning* 6. *Big Data Analytics*	*Root Cause Analysis (RCA)*
Improve	1. 5S 2. *Waste Management System*	1. *Brainstorming* 2. 5S 3. A3	1. *Standard Work* 2. *Kaizen* 3. 5S 4. *Risk Management*	1. *Prototype Testing* 2. *Improvement Plans*
Control	1. *Control Chart* 2. *Statistical Process Control (SPC)* 3. *Standard Operating Procedures (SOP)* 4. *Visual Process Control* 5. *Training Plan*	1. *Standard Work* 2. *Control Chart*	1. *Standard Work* 2. *Kaizen* 3. *Continuous Improvement* 4. *Daily Management*	1. *Standardization* 2. *Statistical Process Control (SPC)*
Transparancy	-	-	-	*Activity-Based Costing*
Accountability	-	-	-	*System of Rewards and Sanction*

Table 12 Approaches and Tools used for implementing Lean Six Sigma in Manufacturing Industry

Phase	Industri *Manufacturing*				
	Automotive	***Hard-Disc Drive***	***Packing***	***Electric Component***	***Food***
VSM (Value Stream Mapping)					1. *Quality Function Deployment (QFD)* 2. *Pareto Chart* 3. *Cost-Benefit Analysis* 4. *Project Selection Matrix*
Define	*Value Stream Mapping (VSM)*	1. *Brain-storming* 2. *Waste Management System* 3. *Sustainability Matrix*	*Project Charter*	*Value Stream Mapping (VSM)*	1. *Brain-storming* 2. *SIPOC* 3. *Project Charter*
Measure	1. *Pareto Chart* 2. *Standard-ization*	1. *Pareto Chart* 2. *Value Stream Mapping (VSM)*	1. *Value Stream Mapping (VSM)* 2. *Quality Tools* 3. *Project Selection*	*Pareto Chart*	*Value Stream Mapping (VSM)*
Analyze	1. *Root Cause Analysis (RCA)* 2. *Problem Solving* 3. *Cause and Effect (C&E) Diagram*	1. *5 Whys* 2. *Statistical Process Control (SPC)* 3. *Control Chart* 4. *Pareto Chart* 5. *ANOVA* 6. *5S* 7. *Kaizen*	1. *5 Why* 2. *Pareto Chart* 3. *Cause and Effect (C&E) Diagram*	*Kanban*	1. *Pareto Chart* 2. *Cause and Effect (C&E) Diagram* 3. *5 Why* 4. *Failure Mode and Effect Analysis (FMEA)*
Improve	1. *Brainstorming* 2. *5S* 3. *Total Productive Maintenance (TPM)*	*Improvement Plans*	1. *5S* 2. *Visual Mana-gement*	1. *Poka-Yoke* 2. *5S* 3. *Visual Mana-gement* 4. *Single Minutes Exchange of Dies (SMED)* 5. *Celullar Manufacturing*	1. *5S* 2. *Celullar Manu-facturing* 3. *Standard Work* 4. *Total Productive Maintenance (TPM)*
Control	1. *Training Plan* 2. *Control Chart*	1. *Statistical Process Control (SPC)* 2. *Control Chart*	1. *Standard Work* 2. *Training Plan*	*Control Chart*	1. *Visual Control* 2. *Statistical Process Control (SPC)*
Transparancy	-	-	-	-	-
Accountability	-	-	-	-	-

	Maintenance (TPM)			3. *Visual Mana-gement* 4. *Single Minutes Exchange of Dies (SMED)* 5. *Celullar Manu-facturing*	3. *Standard Work* 4. *Total Productive Maintenance (TPM)*
Control	1. *Training Plan* 2. *Control Chart*	1. *Statistical Process Control (SPC)* 2. *Control Chart*	1. *Standard Work* 2. *Training Plan*	*Control Chart*	1. *Visual Control* 2. *Statistical Process Control (SPC)*
Trans-parancy	-	-	-	-	-
Account-ability	-	-	-	-	-

5. Conclusion

Based on the results of the Systematic Literature Review of 16 articles about the Relation between Lean Six Sigma and Sustainability, it can be concluded that the relation between Lean Six Sigma and Sustainability in different sectors of the Service Industry and Manufacturing Industry has a positive impact. These various industrial sectors, which is the Service Industry on Governance, Construction, Healthcare, and KPO / BPO (Knowledge Process Outsourcing / Business Process Outsourcing) sectors and the Manufacturing Industry on Automotive, Food, Packing, Hard-Disc Drive, and Electric Component sectors.

In addition, three approaches are used, which is DMAIC (Define, Measure, Analyze, Improve and Control), DMAIC + Transparency and Accountability (DMAIC Modify), and VSM-DMAIC. DMAIC is applied in the Service industry on Construction, Healthcare, and KPO / BPO sectors, and is also applied in the Manufacturing industry on Automotive, Hard-disc Drive, Packing and Electric Component sectors. Then, the DMAIC + Transparency and Accountability (DMAIC Modify) approach is applied in the Service industry on Governance sector, and the VSM-DMAIC approach

is applied in the Manufacturing industry on Food sector. Meanwhile, the tools used depend on each phase and the industry.

The suggestion for businesspeople is the need to apply the Lean Six Sigma method through the DMAIC approach in the Service and Manufacturing industries, DMAIC + Transparency and Accountability (DMAIC Modify) in the Service industry on Governance sector, and VSM-DMAIC in the Manufacturing industry on Food sector. Furthermore, using the recommended tools to conduct rigorous evaluation on process of planning, development, project team management, measurement system analysis, organizational leadership, and communication strategies for achieving sustainability in the company. In this way, companies can identify areas that need improvement and result in cost savings, increased efficiency, improved quality, and better customer service.

References

Aldairi, J., Khan, M.K. & Munive-Hernandez, J.E., Knowledge-based Lean Six Sigma maintenance system for sustainable buildings. *International Journal of Lean Six Sigma*, 8 (1), 109-130, 2017.

Antony, J., Gupta, S., Sunder M., V. and Gijo, E.V., Ten commandments of Lean Six Sigma: a practitioners perspective. *International Journal of Productivity and Performance Management*, 67 (6), 1033-1044, 2018.

Antony, J., Snee, R. and Hoerl, R., Lean Six Sigma: yesterday, today and tomorrow. *International Journal of Quality & Reliability Management*, 34 (7), 1073-1093, 2017.

Cherrafi, A., Elfezazi, S., Chiarini, A., Mokhlis, A., & Benhida, K., The integration of lean manufacturing, Six Sigma and sustainability: A literature review and future research directions for developing a specific model. *Journal of Cleaner Production*, *139*, 828–846, 2016.

Cherrafi, A., Elfezazi, S., Govindan J., Reyes, J.A.G., Benhida, K. & Mokhlis, A., A framework for the integration of Green and Lean Six Sigma for superior sustainability performance. *International Journal of Production Research*, 55 (15), 4481-4515, 2017.

Garza-Reyes, J.A., Green lean and the need for Six Sigma. *International Journal of Lean Six Sigma*, 6 (3), 226-248, 2015.

Flor Vallejo, V., Antony, J., Douglas, J.A., Alexander, P. and Sony, M., Development of a roadmap for Lean Six Sigma implementation and sustainability in a Scottish packing company. *The TQM Journal*, 32 (6), 1263-1284, 2020.

Jamil, N., Gholami, H., Saman, M.Z.M., Streimikiene, D., Sharif, S. & Zakuan, N., DMAIC-based approach to sustainable value stream mapping: towards a sustainable manufacturing system. *Economic Research-Ekonomska Istraživanja*, 33 (1), 331-360, 2020.

Kowang, T. O., Yong, T. S., Rasli, A., & Long, C. S., Case Report Lean Six Sigma Sustainability Framework : A Case Study on an Automotive Company. *Asian Journal of Scientific Research*, *9* (5), 279–283, 2016

Lu, J., Laux, C. and Antony, J., Lean Six Sigma leadership in higher education institutions. *International Journal of Productivity and Performance Management*, 66 (5), 638-650, 2017.

Magon, R. B., Thomé, A. M. T., Ferrer, A. L. C., & Scavarda, L. F., Sustainability and performance in operations management research. *Journal of Cleaner Production*, 190, 104-117, 2018

Motiani, N., & Kulkarni, A., *Sustainability and Impact of Lean Six Sigma Practices : Learnings From Some KPO / BPO Organizations*, *11*, 442–452, 2019

Nunhes, T. V., Ferreira Motta, L. C., & de Oliveira, O. J., Evolution of integrated management systems research on the Journal of Cleaner Production: Identification of contributions and gaps in the literature. *Journal of Cleaner Production*, 139, 1234-1244, 2016

Parmar, P. S., & Desai, T. N., Evaluating Sustainable Lean Six Sigma enablers using fuzzy DEMATEL : A case of an Indian manufacturing organization. *Journal of Cleaner Production*, *265*, 121-802, 2020.

Patel, S., Desai, D. A., Narkhede, B. E., Maddulety, K., & Raut, R., Lean Six Sigma: Literature review and implementation roadmap for manufacturing industries. *International Journal of Business Excellence*, 19 (4), 447-472, 2019.

Powell, D., Lundeby, S., Chabada, L. and Dreyer, H., Lean Six Sigma and environmental sustainability: the case of a Norwegian dairy producer. *International Journal of Lean Six Sigma*, 8 (1), 53-64, 2017.

R., B.R., Vinodh, S. and P., A., Development of structural equation model for Lean Six Sigma system incorporated with sustainability considerations. *International Journal of Lean Six Sigma*, 11 (4), 687-710, 2020.

Resta, B., Dotti, S., Gaiardelli, P., & Boffelli, A., Lean manufacturing and sustainability: An integrated view. *IFIP Advances in Information and Communication Technology*, 2016.

Rowland, B. M., Research and Solutions: Sustainable Urban Governance: Lessons from Katrina and the Lean Six

Sigma. *The Journal of Record*, 1 (5),. 329-334, 2008

Swarnakar, V., Tiwari, A.K. and Singh, A.R., Evaluating critical failure factors for implementing sustainable lean six sigma framework in manufacturing organization: A case experience. *International Journal of Lean Six Sigma*, Vol. Tasdemir, C., & Gazo, R. (2018). A systematic literature review for better understanding of lean driven sustainability. *Sustainability (Switzerland)*, *10*(7), 2020.

Tasdemir, C., & Gazo, R., A systematic literature review for better understanding of lean driven sustainability. *Sustainability (Switzerland)*, *10*(7), 2544, 2018.

Trakulsunti, Y., Antony, J. and Douglas, J.A., Lean Six Sigma implementation and sustainability roadmap for reducing medication errors in hospitals. *The TQM Journal*, 1-23, 2020.

Zhong, Y., & Wu, P., Economic sustainability, environmental sustainability and constructability indicators related to concrete- and steel-projects. *Journal of Cleaner Production*, 108, 748-756, 2015

Zhu, Q., Johnson, S. & Sarkis, J., Lean six sigma and environmental sustainability: a hospital perspective. *Supply Chain Forum: An International Journal*, 19 (1), 25-41, 2018.

Biographies

Sambudi Hamali is a lecturer in Management Department at Binus University since 2014. He is graduated with Doctoral Degree in Management Science from Padjadjaran University. He has experience in various industries, not only in education but also in the construction and services industry.

Diza Iwari is graduated from Management Department, BINUS Business School Undergraduate Program, Bina Nusantara University.

Nabilah Anindya Putri is graduated from Management Department, BINUS Business School Undergraduate Program, Bina Nusantara University.