



A Systematic Literature Review of Six Sigma Implementation in Services Industries

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Six Sigma has received a lot of attention in the industrial sector from the manufacturing industry to the service industry. More in-depth knowledge of Six Sigma has been overgrowing. Many pieces of training and researches on Six Sigma conducted in industries and universities. This literature review aims to present an overview of the implementation of Six Sigma in the service industry. Besides, it can also be useful to obtain information about the benefits achieved, the main difficulties encountered, and lessons that can be taken in the implementation of Six Sigma. Hopefully, this finding will be useful for other service organizations that wish to implement Six Sigma. The Six Sigma method that has long been introduced and implemented is DMAIC (Determine, Measure, Analyze, Improve, and Control).

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1. INTRODUCTION

The business strategy to achieve a competitive advantage is the successful implementation of the quality management system. Statistical Process Control (SPC) and Total Quality Management (TQM) play an essential role in the industry as a general quality approaches or quality initiative. Currently, Six Sigma is one of the most popular quality initiatives in the industrial sectors. Six Sigma has overgrown in various industrial industries since the introduction of Carl Frederick Gauss (1777-1885), the first person to introduce the standard curve in statistics. This concept was later developed by Walter Shewhart in 1920, explaining that three Sigma mean values indicate the need for improvement in a process

(Ramasubramanian, 2012).

Six Sigma breakthrough strategies emphasize reducing cycle time and increasing customer satisfaction in determining the level and cost of optimal service quality. Six Sigma's implementation for the service industry is relatively new compared to the application of Six Sigma to the industrial sector (Frings & Grant, 2005). Generally, Six Sigma implementations are carried out in the manufacturing industry to reduce the variability in the process, thus giving customers a more reliable organization, product or service, and less error (Ismayrlis & Moschidis, 2013). Companies that implement Six Sigma often face significant challenges when working to

implement quality programs effectively in many complex industrial processes and services. The application of Six Sigma to companies operating in the service industry has gained more attention by increasing mergers and acquisitions among entrepreneurs to make the organization efficient.

2. LITERATURE REVIEW

Six Sigma is a statistically significant measure of variation in a process. Six Sigma is full of 99,9997 percent accuracy. Six Sigma is a methodology for improving key processes. Six Sigma is a quality "toolbox" and a management tool for solving problems focused on continuous improvement (Krishnan & Prasath, 2013). In the Six Sigma level practical methodology, this means 3.4 defects per million opportunities or 3.4 DPMO (Defect Per Million Opportunity), which means that the success rate reaches 99.9997 percent. It is, of course, assumed that the data follow a normal distribution and also given that the average process tends to float at an average of 1.5 sigma from the tolerance limit or specification (Figure 1).

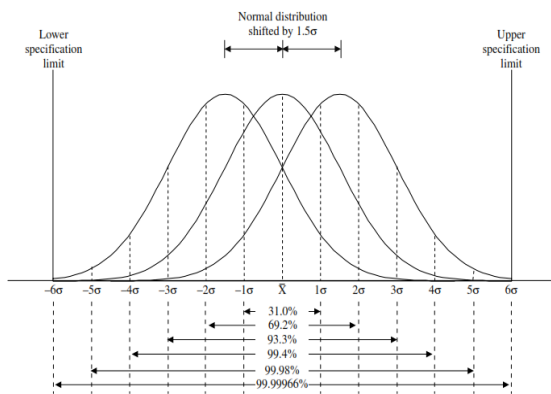


Figure 1. Shifted normal distribution and corresponding quality level

Generally, Six Sigma implementations are carried out in the manufacturing industry to reduce the variability in the process, thus giving customers a more reliable organization, product or service, and less error (Ismaylis & Moschidis, 2013). Companies that implement Six Sigma often face significant challenges when working to implement quality programs effectively in many complex industrial processes and services. The application of Six Sigma to companies operating in the service industry has

gained more attention by increasing mergers and acquisitions among entrepreneurs to make the organization efficient.

3. RESEARCH METHOD

This research aims to explore deeper into Six Sigma's implementation in the services industries. The study was carried out using the Google Scholar database. With the research goals in mind, the terms 'Six Sigma' and 'Service Industries' were used to search for articles. Since Six Sigma is a relatively new topic, no date ranges were used to limit the search.

A thorough search of peer-reviewed literature was conducted, and the findings were compiled and sorted into several categories about Six Sigma in service industries. The literature is studied in many ways to understand how Six Sigma is applied in various fields, particularly its main interest in learning Six Sigma in its service and development. This paper aims to outline knowledge about the value of Six Sigma in the industry, consider Six Sigma as an organizational strategy, and seek ways to gain insight into the subject.

This paper follows the basic research steps including; literature review regarding developments of Six Sigma; formulating a classification framework; employing the classification framework to conclude the developments of Six Sigma; presenting the literature review using the classification framework to organize the review; identification of gaps and suggestions for future research.

The implementation of Six Sigma provided a definite improvement of the quality of service. It streamlined the process by eliminating any source of waste while taking into account the digitization imperative (Bernardo, 2013). Timeliness, lead time, and human factors are necessary performance measures. However, maybe in a particular kind of service industry, these performance measures can significantly change (Modi & Doyle, 2012).

The following keywords were used such as six Sigma, six Sigma in services, six sigma application in services, quality initiatives in

services, quality innovation in services, six Sigma, and quality control, and services and six Sigma. A total of 75 journals of six Sigma in service industries was collected and reviewed. The text of each article was reviewed to eliminate articles that are not related to the "six sigma application" in services. For example, articles were removed that focused on manufacturing industries or discusses manufacturing and services in the same flow. About 50 articles related to six sigma applications in services were considered. In the case of citation analysis, only articles from journals on Google Scholar were considered.

3.1. Approach and phases

In this paper, the approach includes ten fundamental processes for conducting a systematic literature review: (1) Research purpose and objective: the purpose and goals are clearly identified after a review of the most common gaps in the literature. (2) Develop research protocol: the protocol includes the study scope, strategy, criteria, quality assessment, and data extraction, and so on. This

protocol will be followed during the systematic literature review process. (3) Establish relevance criteria: the research criteria help ensure that we include only the papers most relevant to the research question, and exclude unrelated papers. (4) Search and retrieve the literature: electronic research for pertinent articles of top academic and specialist journals, and hand research in bibliography lists. (5) Selection of studies: dependent on research criteria. (6) Quality assessment for relevant studies: using appropriate tools to assess articles for quality. Each article should be scored for its quality, depending on the methodology used. (7) Data extraction: extract the relevant data from each study included in the review. (8) Synthesis of studies (analysis): using appropriate techniques, such as quantitative or qualitative analysis, or both for combining the extracted facts. (9) Reporting: reporting the systematic literature review in detail as well as the results of the review. (10) Dissemination: publishing the systematic review in an academic journal to contribute to knowledge in the field (Figure 2).

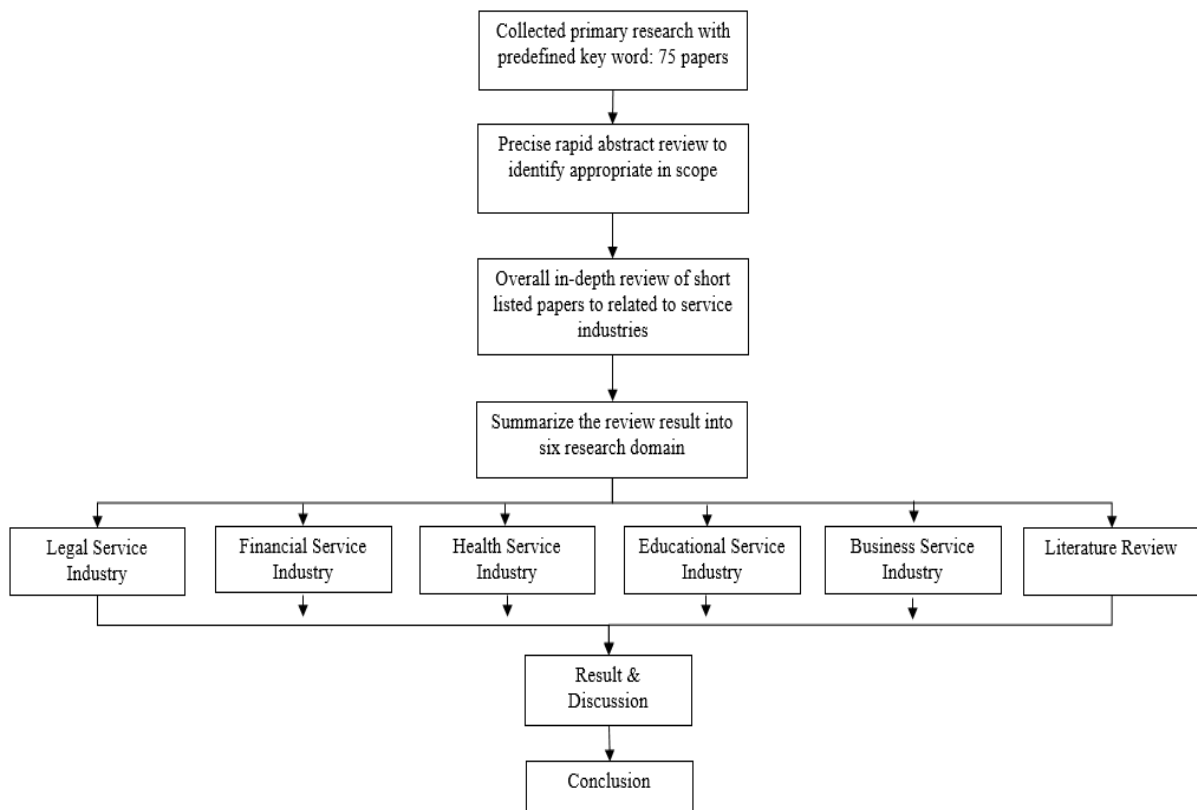


Figure 2. Study framework

3.2. Criteria

Inclusion and exclusion criteria are stated to make it clear to the reader why some articles with which they are familiar have been excluded from the review (Booth et al., 2012).

3.3. Material and outcomes

The journal search for research literature was done through 75 academic journals that are published in public databases: Emerald, Inderscience, Elsevier, IEEE Xplore, John Wiley & Sons, and ProQuest. Search strings have been used, such as six sigma or service sector or service industry. Meanwhile, the literature search was limited to the English language only. However, some journals were excluded from the review due to the absence of related articles to the research criteria.

This search of journals and databases illustrated that there were no research articles related to SS to be found before 2005. This result has been supported by many researchers who have reported that there was no SS publication to be found before the year 2005. The most common themes that emerged in the literature are benefits, motivation factors, limitations, impeding factors. These themes have been presented in this paper, as they are the most common themes in literature (Table 1).

Table 1. Research criteria

Inclusion	Exclusion
Articles published during 2005 to 2019	Any publication before 2005
Academic Journals	Books and online sites

4. RESULT AND DISCUSSION

The 50 journals of the Six Sigma implementation in the service industries were selected for review (Table 2). The selected journals or articles were analyzed from the aspect of Six Sigma methodologies, consist of Six Sigma basic concepts and Six Sigma enhancement, then also analyzed by research object and the result for following review of selected articles. How Six Sigma methodologies were used, how Six Sigma basics concepts were applied, and how benefits were generated. Six Sigma is a structured methodology for continuous process improvement and operational excellence (Schroeder, Linderman, Liedtke, & Choo, 2008). Excessive statements that often accompany Six Sigma's presentation and application in the industry can lead to unrealistic expectations of what Six Sigma can achieve. In addition to the traditional Six Sigma statistical and financial tools, Six Sigma emphasizes "cultural change" and people's skills (Zu & Fredendall, 2009).

Table 2. Existing literature review of six sigma in service industries

No	Paper Identity	Research object	Result
1	Frings & Grant (2005)	Health Service Industry	Increasing sigma level in medical service
2	Chakrabarty & Tan (2007)	Literature review	The CSFs, CTQs, and KPIs as three aspects are important considerations in the application of six sigma. As the focus is more on studies concentrating on a particular service.
3	Jiju, Frenie, Maneesh, & Byung (2007)	Literature review	The average sigma quality level of the companies was around 2.8 (approximately 98,000 DPMO)
4	Taner, Sezen, & Antony (2007)	Health Service Industry	Appropriately implemented, six sigma clearly produces benefits in terms of better operational efficiency, cost-effectiveness and higher process quality.
5	Abdolshah, Yusuff, Ismail, & Hong (2009)	Literature review	Approach to Six Sigma phases with considering customer and operational strategies in service industries.

Table 2. Existing literature review of six sigma in service industries (continued)

No	Paper Identity	Research object	Result
6	Ozcelik (2010)	Legal Service Industry	Provides compelling evidence that expanding the scope of traditional Six Sigma methodology from manufacturing to service sector has been quite successful.
7	Wang & Chen (2010)	Financial Service Industry	Cost saving of US\$828,000 and obvious enhancement of short-term and long-term process capability from 0.86 and 0.57 to 2.04 and 1.51.
8	Laureani, Antony, & Douglas (2010)	Business Service Industry	The 3 per cent decrease in unresolved queries after first contact resulted in 36,000 fewer calls to the Call Center on an annual basis (36,000 = 3 per cent of 1,200,000)
9	Catarina, Marlene, & Manuel (2010)	Financial Service Industry	The benefits derived from its implementation, such as lowering the operational costs, improving processes and product quality, increased efficiency, which leads to the increase of productivity, the agility and versatility obtained by the organization
10	Sony & Naik (2011)	Literature review	Benefits through Six Sigma in Indian service industry along with the industries wise implementation status for service performance improvement.
11	Wang & Chen (2010)	Financial Service Industry	The application of Six Sigma methodology with TRIZ performs effectively in the improvement of banking services.
12	Neves & Nakhai (2011)	Financial Service Industry	Six Sigma approach provides an effective framework for learning about the customers and for implementing both quality and innovation.
13	Psychogios, Atanasovski, & Tsironis (2012)	Business Service Industry	Six Sigma successfully implemented in telecommunication industries.
14	Modi & Doyle (2012)	Business Service Industry	Benefits identified by this research suggest that it could be a worthwhile initiative for companies interested in IT.
15	Chiarini (2013)	Literature review	Timeliness, lead time and human factors are important performance measures. However, maybe in a particular kind of service industry these performance measures can significantly change.
16	Prasanna & Vinodh (2013)	Literature review	The production lead time decreased 425 to 242 min
17	Nicoletti (2013)	Business Service Industry	Implementation of Six Sigma provides an accurate improvement of the quality of service and streamlining of the process by the elimination of any source of waste.
18	Matthew (2013)	Health Service Industry	Six Sigma's overall effectiveness and the value it offers to healthcare.
19	Blick (2013)	Health Service Industry	Increasing productivity, keeping pace with a 6% to 8% annual increase in testing volume, without adding technologists.
20	E.V., Jiju, Jose, & Johny (2013)	Health Service Industry	The average waiting time reduced from 24 minutes to 11 minutes
21	Kokkranikal, Antony, Kosgi, & Losekoot (2013)	Health Service Industry	Resistance to change can be overcome by thoroughly convincing people of the real benefits that lie in the process and this can be achieved by involving people in projects.

Table 2. Existing literature review of six sigma in service industries (continued)

No	Paper Identity	Research object	Result
22	Sharabi (2013)	Educational Service Industry	Six Sigma contribute to improving the service quality within the organization in order to succeed in a competitive environment
23	Paulo & Marly (2014)	Literature review	Six Sigma program was implemented considering the existing quality and improvement programs, which helped with the implementation
24	Omar & Mustafa (2014)	Literature review	There are some benefits of SS such as increased customer satisfaction; increased employee morale; improved cross- functional teamwork across the organization; improved consistent level of service; and increased awareness of problem solving tools and techniques.
25	Tenera & Pinto (2014)	Supply Chain Service Industry	Six Sigma (SS) project management process improvement model and a case study test developed in a real enterprise environment which has a formal and established project management system PMI based.
26	Shreeranga, E.V., & N.A.(2014)	Health Service Industry	Cycle time has reduced from three to 1.5 minutes. The sigma level of the process showed improvement from 0.53 to 3.69
27	Sunder (2014)	Financial Service Industry	The methodology has many aspects of success and stakeholder management becomes the key element for the success of any SS project
28	Mishra & Sharma (2014)	Supply Chain Service Industry	The substantial improvement in process Z before (1.71) and after (2.38) resulted in financial savings of approximately 223,750 units in total.
29	Ellis, Goldsby, Bailey, & Oh (2014)	Supply Chain Service Industry	The results of two structural equation models (IBM SPSS AMOSv.21), which showthat participation (Model 1, $\beta = .385$, $p .001$) and organizational learning identification (Model 2, $\beta = .234$, $p .001$) are positively related to perceived
30	Antony (2015)	Financial Service Industry	Cost saving about USD 0.27 million
31	Asnan, Nordin, & Othman (2015)	Literature review	By managing the issue in change and preparing complete change program can help in ensuring the implementation process in service industries move smoothly and successful.
32	Mohamed & Mumtaz (2015)	Educational Service Industry	Six Sigma and DMAIC framework worked well for the process analysis and improvement in the university FM services to improve both operational efficiency and effectiveness for FM departments at universities
33	Holmes, Lawrence, & Hempel (2015)	Educational Service Industry	The weighted scorecard method would have been a useful approach for thinking about how to select the project which might provide the most significant results on campus
34	Andrés-López, González-Requena, & Sanz-Lobera (2015)	Literature review	The application of Six Sigma philosophy through the increase of organizational competitiveness and customer satisfaction, and the reduction of process variability and wastes.

Table 2. Existing literature review of six sigma in service industries (continued)

No	Paper Identity	Research object	Result
35	Muturi et al. (2015)	Financial Service Industry	Recommendation to SS implementation needs top management commitment, organizational culture change, effective communication, link to strategy and training as the main critical success factors for its successful implementation.
36	Lande, Shrivastava, & Seth (2016)	Literature review	Important Critical Success Factors in Six Sigma is Training as greater impact by 13.1% of occurrences.
37	Vijaya (2016)	Educational Service Industry	Reinforcing the fact that SS methodology could lead to lower defects and higher customer satisfaction.
38	Leopoldo, Sander, & Ruud (2016)	Supply Chain Service Industry	Implementing Six Sigma in the logistics industry as in the manufacturing industry by reduced process cycle time
39	Abraham, Wen, Yangyan, Ting, & Xavier (2016)	Supply Chain Service Industry	Implementers realized cost savings of 1~6%.
40	Kholopane (2016)	Supply Chain Service Industry	The process in the company was improved significantly.

Most published articles from emerald publishers (Figure 3) from the 2009-2019 publications (Figure 4). Six Sigma can be considered a recent quality improvement initiative that has gained popularity and acceptance in many industries globally (Nonthaleerak and Hendry, 2005). Six Sigma, when applied to the Global Supply Chain, eliminates unnecessary processes and defects in the produced goods, which increases the overall efficiency of the global supply chain. Industry 4.0 helps to improve the efficiency of production and supply by automation and exchange of data between the manufacturing and logistics systems (Jayaram, 2016).



Figure 1. Number of publisher

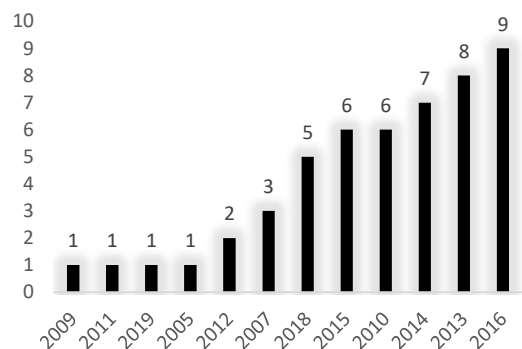


Figure 2. Years of publication

This study showed that irrespective of differences across services, there are some similarities among these parameters, which provide a fundamental basis for service organizations to apply six sigma. Six sigma is slowly but surely finding structured and beneficial applications in service industries (Chakrabarty & Tan, 2007).

4.1. Distribution of Publication

It is analyzing the distribution of publication of Six Sigma implementation on the service industry for by regions being identified (Figure 4). Asia has registered the most significant number of publications with 20 papers. And this is followed by Europe with 15 papers, America

with 11 papers, Australia and Africa both with two papers.

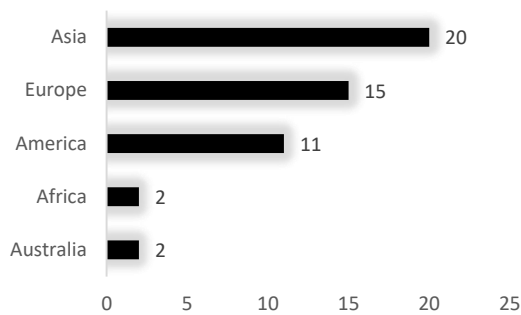


Figure 3. Number of publication by region

4.2. Six Sigma Paper Themes

In this section of the paper, tables and figures are used to illustrate the result. Six Sigma papers implemented in the service industry were found to have included different contents and themes (Figure 5). The literature review by the researcher was the most exciting topic for Six Sigma implementation in the service industry with the number of publication is 14 papers, financial service industry with nine papers, health service industry and supply chain with 8 papers, business service with six papers, educational service with four papers and legal service with one paper.

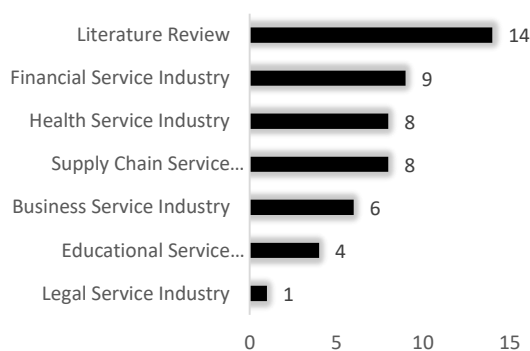


Figure 4. Papers publication by focus area of research

4.3. The Benefit of Successful Implementation of Six Sigma in Service Sector

A review of 50 Six Sigma papers showed that 9 case studies were published in the financial service sector, 8 case studies in both health service and supply chain, and the rest in

business service, educational, and legal services. The analysis of Six Sigma benefits in the service sector in Table 2. and the top benefit cited in the paper are:

1. Increase profits and financial savings.
2. Increase customer satisfaction.
3. Reduce cost.
4. Reduce cycle time.
5. Reduce waste.
6. Reduce defects.
7. Reduce inventory.
8. Improve quality.
9. Increase production capacity.
10. Improved process.

In the supply chain sector, as in the manufacturing industry by reduced process cycle time, improved delivery performance, reduced inventory, and other benefits. Most logistics implementers realized cost savings of 1~6% (Abraham, Wen, Yangyan, Ting, & Xavier, 2016). The company's process was improved significantly. This also brought the team together to achieve a goal of providing solutions to issues, thus meeting the on-time performance target and delivering safer and right quality products to customers (Kholopane, 2016).

4.4. Motivation Factors for Six Sigma Implementation.

The real economy in several countries involves such fields as financial services, health care, e-commerce, and logistics, but less manufacturing, which has tended to move offshore to low-cost locations. Six Sigma can be used to reduce the costs of poor quality so that a more consistent process for service delivery may be achieved. Another important reason for introducing the six sigma strategy in many service companies is that customers of today feel "process variability" in the delivery of the service provided and not just on "process average or mean". The objective of a six sigma strategy is to reduce "process variability" around the acceptable target service performance.

There are several different factors for companies to apply Six Sigma in their organizations. In most cases, a common reason for deploying six Sigma is to change the competitive position in the market or stay in the

competition in the international market. Increasing customer satisfaction, loyalty, and attraction and improving the quality of product and production.

However, these organizations may not be aware of all the Six Sigma possibilities for improvement in the different departments in their organizations. This illustrates the lack of organizations' awareness of Six Sigma benefits. Authors argue that a strong relationship between motivation and profit as a lack of motivation leads to fewer profits. The motive of an organization can be increased by using the success stories of other companies and understanding their motivational factors to deploy.

4.5. Gaps in the Current Literature on Six Sigma and Agenda for Future Research

Particular factors influence the implementation of Six Sigma in organizations, that can be distinguished in facilitators like Top Management Involvement & Support, Quality-driven Organizational Culture, Quality-driven Training, Top Down & Bottom Up Project Selection, Customer Satisfaction, Prior implementation of other quality improvement programs and Supportive Performance Management & IT Systems, and inhibitors such as Lack of Awareness for Six Sigma, Lack of Awareness for the Need of Continuous Quality Improvement Programs & Six Sigma, Lack of Strategic Orientation, Working Mentality & Habits (Psychogios, Atanasovski, & Tsironis, 2012). Future research is needed to assess the criticality of some factors that appeared in a small number of cases explored in this research.

These factors include weak linking of the LSS strategy to suppliers (Bamber and Dale, 2000), the lack of understanding of how to start (Kumar et al., 2009), the lack of application of statistical theory (Thomas et al., 2009) and so on. Future research is also needed to identify the critical failure factors for SS deployment about countries' evolution (developed and developing countries), industry (public, service, health care, higher education, and manufacturing) and organizations' size (SMEs and large organizations). Furthermore, there is a shortage of publications on quality improvement, especially in the LSS area in higher education.

Searching four databases resulted in one paper that met the research criteria published in 2012 by Antony et al. Finally, there is a significant need for a measurement system for SS performance, as most organizations fail due to the lack of a Six Sigma maturity model. More research is needed to address the current gaps in the literature.

4.6. Industry 4.0 and IIoT

Industry 4.0 is the fourth industrial revolution based on computerized manufacturing systems. It has a cyber-physical policy, which is a combination of software and production assets. Futures research shall include automation, Industrial Internet Things (IIoT), data sharing, and cloud computing. IIoT focuses on industrial automation, device communication, data flow, device administration, device integration, and predictive analytics. Industry 4.0 can be implemented in the Global Supply Chain, along with IIoT, IoT, sensors, and cloud storage. IIoT is the application of the Internet of Things (IoT) in industries. Industry 4.0 focuses on supply chain coordination, robots, embedded systems, and automation (Jayaram, 2016). Comparison of Industry 4.0 and IIoT is shown in Table 3.

Table 1. Comparison of Industry 4.0 and IIoT

Comparison of Industry 4.0 and IIoT	Industrial Concepts	
	Industry 4.0	Industrial Internet of Things (IIoT)
Technological Objective	Supply chain coordination, automation, embedded systems, robotics	Industrial automation, device communication, device administration, device integration, predictive analytics, data flow
Area of implementation	Hardware	Hardware, software, integrated
Enterprise Size	Ideal for small and medium enterprises	Ideal for all enterprises
Area of Optimization	Production	Assets

5. CONCLUSION

Six Sigma is a structured methodology for improving a process focused on efforts to reduce process variance as much as possible minimize disability (products/services that are outside the specifications) with use statistics and problem-solving tools intensively. The

main focus of Six Sigma as a management system is on three matters, which are the focus to customer, process, and data management. In Six Sigma, customer satisfaction is the main focus. The six sigma methodology has been successfully applied in many organizations leading to an increase in exceptional quality in products manufactured and services provided. However, service industries have lagged behind other organizations in implementing Six Sigma. Implementation of Six Sigma in service industries different from the application in the manufacturing industry, so it needs some adjustment.

The successful application of the methodology in an organization requires commitment from top management and employees. Top management becomes the champion for the method does the necessary resources that are needed to institutionalize the methodology. Employees make sure that they study, use, and appreciate the technique for ensuring successful implementation. This study showed that irrespective of differences across services, there are some similarities among these parameters, which provide a fundamental basis for service organizations to apply six Sigma. Six Sigma is slowly but surely finding structured and beneficial applications in service industries.

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