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A Systematic Literature Review of Six Sigma Approach in Manufacturing and Services Industries in Indonesia

Edna Maryani[1*], Choesnul Jaqin[2], Salmon Tampubolon[2]

[1]Industrial Engineering Program, Universitas Faletehan, Jl. Raya Cilegon Km.6 Kramatwatu Kabupaten Serang, Banten 42161 Indonesia

[2]Master of Industrial Engineering Program, Mercu Buana University Jakarta, Jl. Raya Meruya Selatan No. 1 Jakarta 11650 Indonesia

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A B S T R A C T

The present work is a review of literature, to identify the improvements acquired from the application of the Six Sigma methodology in manufacturing and services industries in Indonesia. This systematic review intends to identify how manufacturing research is contributing to the development of the Industry in Indonesia agenda and for a broader understanding about the links between the manufacturing and services sectors. This systematic review intends to identify by mapping and summarizing existing research efforts, identifying research agendas, as well as gaps and opportunities for research development. The papers were selected base on relevant articles to the topic of work, and the bibliographic databases used for the research were the Google Scholar, ScienceDirect, ResearchGate, etc. The study counted on 50 articles to better exemplify these points, being 36 focused on the manufacturing sector and 14 on the services sector. In both sectors the variability of the process, improving process quality, productivity, efficiency, the service provided, increasing customer satisfaction, reducing costs, timeliness. It has been found that Six Sigma is a versatile tool that can be adapted and applied in any segment, allowing potential opportunities for new research and applications. Basic tools for brainstorming such as Pareto analysis and cause-effect analysis are definitely used in both industries: manufacturing and service.

***Corresponding Author**

Edna Maryani

E-mail: edna.ars22@gmail.com

1. INTRODUCTION

Global competition challenges organizations from different parts of the world and from all sectors. As an attempt to respond to the pressure created by this rivalry, companies have been adopting competitive and innovative methods that, in most cases, tend to emphasize quality and customer focus. The use of quality methods is increasing. In addition to its focus on quality, product, service and process improvement, most of these approaches also focus on customer satisfaction. Nowadays, Six Sigma method becomes a popular method in Quality Management area due to its benefits in the quality improvement. Six Sigma methods are expected to be used in the failure of

remanufacturing lift arm products in the Heavy-duty industry in Indonesia to be reduced so that the process capability is getting better, COPQ can be suppressed and will certainly increase company profits (Saryanto et al., 2020).

The application of Six Sigma in the company will have a good impact both for the company itself and for the consumers or suppliers of the company. By using six sigma method, XYZ milk industry can maintain the consistency of the products and meet the quality demand of consumers throughout Indonesia (Rawendra & Puspita, 2020). The Six Sigma approach looks at the final product, assesses defects in products and looks for ways to eliminate the causes behind defects (Ngatilah et al., 2018).

Six Sigma is a rigorous, focused, and highly effective implementation of proven quality principles and techniques. Incorporating elements from the work of many quality pioneers, Six Sigma aims for virtually error free business performance. Six Sigma is the application of the scientific method to the design and operation of management systems and business processes which enable employees to deliver the greatest value to customers and owners (Pyzdek & Keller, 2010).

Six Sigma is a strategic business improvement approach that seeks to increase both customer satisfaction and a company's financial health. Six Sigma seeks to improve bottom line profits by reducing the hidden costs of poor quality. The immediate benefits enjoyed by businesses implementing Six Sigma include operational cost reduction, productivity improvement, market share growth, customer retention, cycle-time reduction and defect rate reduction (Tang et al., 2006).

2. RESEARCH METHOD

The review of scientific article publications was carried out from several sources, namely: Google Scholar, ScienceDirect, ResearchGate, etc. The types of publications analyzed were manuscripts in the form of journals and proceedings. A preliminary analysis of the selected articles with complete and accessible texts, accepting those that meet the following criteria: 1). Case study articles using Six Sigma; 2). Articles that provide information on how Six Sigma was applied in solving problems in the service and industrial sectors in Indonesia. The study framework of this research:

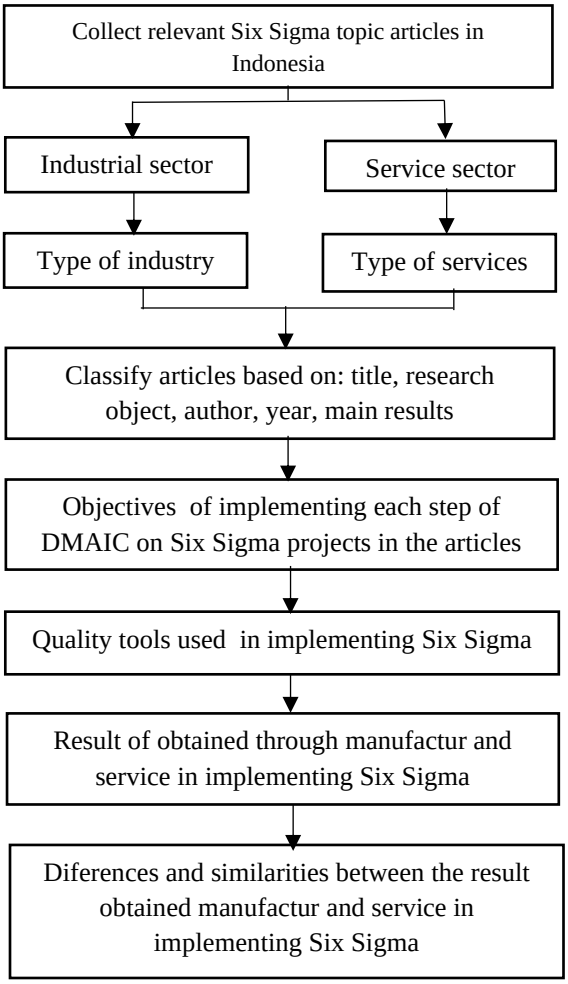

Figure 1. Study framework

The methodology used to build the work is based on the combination of keywords in several databases. As the research deals with the application of the Six Sigma tool in the industrial and service sectors in Indonesia for the research criteria.

The analysis will go through the following steps: separation of case studies according to industry, industry or services; the analysis of the sectors will be done separately, considering the following items: (1). Type of sector that was applied; (2). Purpose of the case studies; (3). Tools used in the implementation of Six Sigma; (4). Objectives of implementing each step od DMAIC; (5). Results obtained after the practice of Six Sigma; (6). Differences and similarities between the two sectors.

3. RESULT AND DISCUSSION

The 40 articles selected for analysis deal exclusively with the use of the Six Sigma methodology, through case studies of companies in the manufacturing and services sectors in Indonesia. The artticles of Six Sigma approach in manufacturing sectors had the biggest number than services sectors articles. There are 31 articles of Six Sigma in manufacturing and 9 articles of Six Sigma in services. All articles in which the study was applied in Indonesia companies. The papers distribution over the years is as shown in Figure 2.

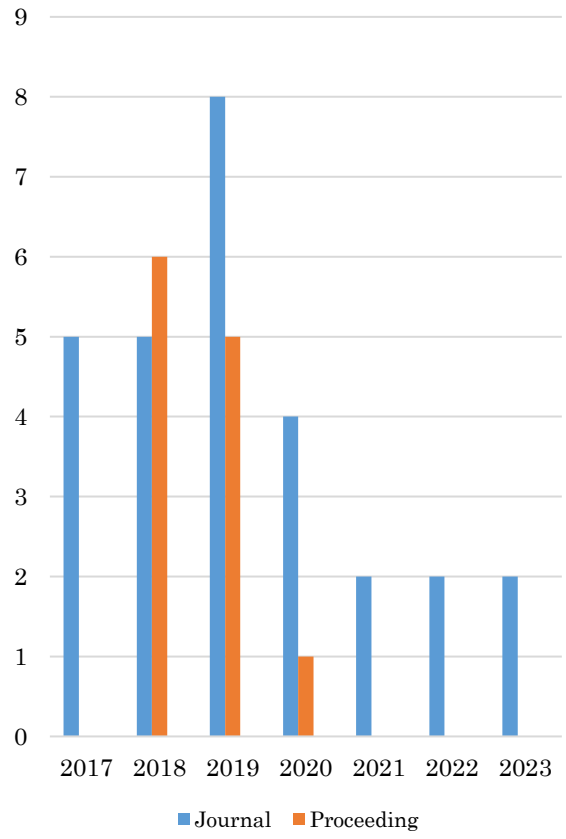

Figure 2. The papers distribution chart

In Fig. 2 that the papers distribution from 2017 until 2023 which the types of publications analyzed were manuscripts in the form of journals and proceedings. The journals and proceedings of the most many in the year 2019, 12 papers. The Six Sigma allows the use of various quality tools in its implementation. The publisher of research is as shown in Figure 3.

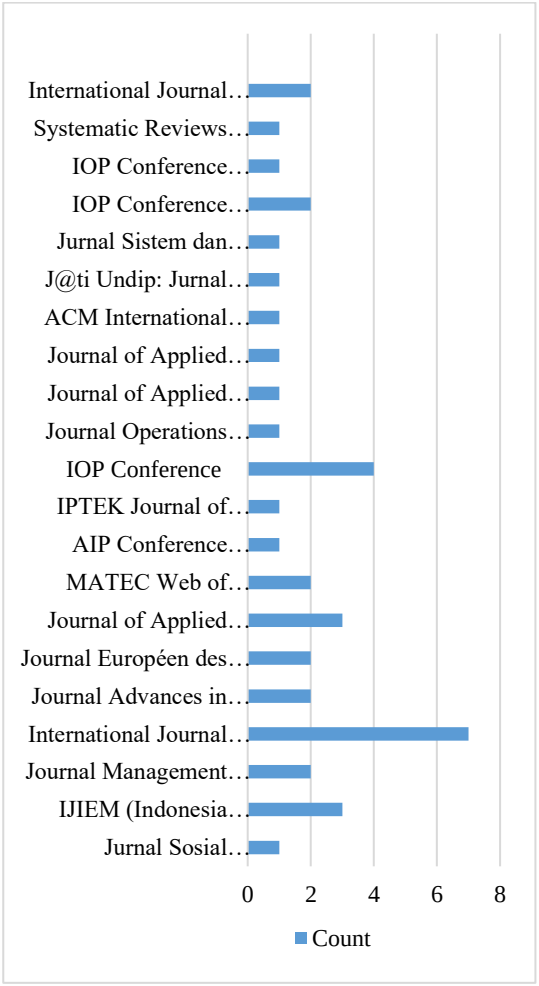

Figure 3. The publisher of research chart

In Figure 3 that some publizer of research of Six Sigma approach in manufacturing and service industries in Indonesia. The International Journal of Innovative Science is most to publizer of research. The Six Sigma allows the use of various quality tools in its implementation. The selected items from the industrial sector, the main tools used in the Six Sigma methodology, is shown in Table 1. It was observed that the tools used among the stages of tool DMAIC (Define, Measure, Analyze, Improve, Control) were distributed as follow: *Define* : VoC, VoB SIPOC, CTQ; *Measure*: process capability, DMPO, sigma level before improve; *Analyze*: Cause & Effect FMEA, Pareto; Improv; *Control*: Control Chart, sigma level after improve. The mapping Project of Six Sigma on DMAIC in manufacturing industries is as shown in Table 1.

Table 1. Mapping Project of Six Sigma on DMAIC in manufacturing industries

Manuscript Identity	Define	Measure	Analyze	Improve	Control	Main Result
(Sjarifudin et al., 2022)	Pareto, CTQ	Sigma level	Fishbone diagram, Control chart	FGD, 5W+1H	Control chart	increased the level of sigma from 3.5765 to 3.7839, so there is an increase of 5.48%.
(Trimarjoko et al., 2019)	SIPOC, CTQ, BLP	Four block diagrams of sigma level	NGT.Shainin system method, cause effect diagram	FMEA	Four Block diagrams of sigma level	reduce cost from IDR.1.427.500.000. to IDR.161.000.000., which means 88.69% decreased.
(Prastyo & Rimawan, 2018)	SIPOC, CTQ	Map control, pareto	Fishbone diagram	FMEA, experiment	Control plan	the thin depot painting (40.1%), dirty (10.9%.), Lime skin (2.1%), bruntus (1.9%).
(Irwanto et al., 2019)	Process observation	Cp and Cpk	Histogram, Mean, standard deviation	Implemented on plan	Control plan	a good filling capability: Cp: 1.67 and Cpk: 1.67.
(Rimawan et al., 2019)	SIPOC, CTQ	DPMO Sigma level	Cumulative percentages Pareto, fishbone diagram	FMEA	Control plan	level Sigma = 4 DPMO = 11263.93 Kg DPU = 0.02 DPO = 0.005 and Percentage of Yield% = 96%
(Purowenang & Rimawan, 2018)	SIPOC, CTQ VoC, VoB	Weibull analysis	Pareto, Ishikawa diagram	FMEA	Process control system	the losses to be experienced in the amount of US $ 1,800,000 can be avoided.
(Kurnia et al., 2022)	Pareto Diagram, CTQ	DPMO value Sigma level	Fishbone diagram, FMEA	5W+1H, Six Sigma level	KPI	increasing the sigma level by 10% from 3.3339 to 3.6832.
(Aditama & Imaroh, 2020)	SIPOC, CTQ	P-control chart, pareto diagram	Fishbone diagram	5W + 1H, FMEA	Application of SOP	increase in Productivity to 4,241 (from August - October 2018)
(Rozak et al., 2020)	OEE achievement	Six big losses pareto diagram	Fishbone diagram FMEA	Improvement schedule	OEE improvement decreasing	increasing OEE value from 87% became 92%.
(Maryani et al., 2021)	5W 1H, VOB, CTQ	P chart, Cp Sigma	Pareto, fishbone diagram, 4M+1E	FMEA	Control plan, SOP	sigma level = 3.6 to sigma level = 3.9.
(Hardiansyah et al., 2019)	Project charter, SIPOC diagram VOB	Pareto diagram	Fishbone diagram	Root potential problems	SOP Run Chart Improvement From	The average cost spent in the Waste Water Treatment department is less than the target of max
(Hernadewita et al., 2019)	VoC, VoB	CTQ, Sigma level	Pareto, Fishbone diagram	Implemented on plan	Control plan	sigma 3.6 or DPMO of 15919.63613. The type of defect 59%, does not register at 29% and paper cut by 12%.
(Rimantho et al., 2017)	SIPOC, CTQ	Process capability	FMEA, Fishbone diagram	5W+1H technique	Control chart	an increased in the sigma level from 2.30 into 4.69.

Table 1. Mapping Project of Six Sigma on DMAIC in manufacturing industries (continued)

Manuscript Identity	Define	Measure	Analyze	Improve	Control	Main Result
(Saryanto et al., 2020)	SIPOC diagram, CTQ (pareto diagram)	Sigma Level, Four Block diagram, COPQ	Brain storming, Fishbone diagram	5W 1H Method	Sigma Level, Four Block diagram, COPQ	73.5 to 7.03% with an increase in quality from 1.91 to 2.43 Sigma.
(Rawendra & Puspita, 2020)	SIPOC Diagram	Pareto Diagram P Chart Sigma level	Fishbone diagram	Matrix parameters	Carbon Test Paper	improvement increased sigma level from 4.58 to 4.79. This
(Ngatilah et al., 2018)	Histogram	CTQ Pareto	Causal diagram	Kaizen five M checklist	Sigma Level	sigma values that deform 19 concrete iron products are included in the industry average
(Herlambang, 2020)	Project charter	Orthogonal arrays Process capability	t-test Box plot sample	Taguchi Matrix with array design	Sigma Level	there is an increase in the population value of performance Pp by 3.36 and Ppk by 1.58
(Kristanto & Wiguna, 2018)	Sigma Level	Process Capability P chart	Diagram of Mean	Recommendations for action to defect structure QFD	Standard deviation and Absolute Error, Sigma level	after the simulation of recommendations for improvement sigma level to 3.48.
(Wijaya et al., 2018)	CTQ SIPOC	Sigma level	FMEA Fishbone diagram	5W1H	Fraction of Defect Control Chart	the sigma score respectively of 2.84σ and 3.81σ.
(Shafira & Mansur, 2018)	SIPOC	Sigma level U Chart	Process capability Fishbone diagram	FMEA AHP 5S	Sigma level	the result of sigma level is 3.3.
(Adriyanti & Vanany, 2019)	SIPOC Project chapter	Sigma level Process capability	Five Whys diagram	FMEA	Sigma level	an increasing sigma level from 3.72 to 3,97.
(Rinawati et al., 2019)	SIPOC	Pareto diagram	Fishbone diagram	KAIZEN activity	Sigma level	the value of 54.330 with the sigma value of 3.103σ
(Rimawan & Pratama, 2018)	CTQ	Sigma level Pareto diagram	NP control chart Fishbone diagram	FMEA	Sigma level	an increasing sigma level 3.87
(Rofiudin & Santoso, 2018)	Process mapping	Validity Project Y	Logic Tree analysis	Testing of capability analysis	Standardize Monitoring	takt time reduce, 9.2s to 8.5s
(Mukhlis et al., 2023)	CTQ, SIPOC, Histogram	Capability, The Cause and Effect Diagram	Pareto	5W+1H	Fishbone diagram, Sigma level	increase in the sigma value from 4.65 to 5.04

The list of journals and conferences of Six Sigma approach in manufacturing sectors represented in the sample is available on Table 1, allowing to identify a list of addressed topics: from efficiency to effectiveness (Rozak et al., 2020); productivity (Aditama & Imaroh, 2020) (Trimarjoko et al., 2019); innovation (Valdi et al., 2019) (Ridwan & Noche, 2018); quality control (Rimawan et al., 2019) (Maryani et al., 2021).

In the Table 2. shows that the tools in the Six Sigma method in the service industry to difficult to implement a complete DMAIC pattern for improving performance.

Table 2. Mapping project of Six Sigma based on DMAIC in service industry

Manuscript Identity	Define	Measure	Analyze	Improve	Control	Main Result
(Shonhadji, 2017)	Process map	Sigma level CTQ, Process capability	FMEA	Implementation of improvement	Control chart	Reduced the quality cost of Rp 120.812.023, 51 to Rp 85.004.510, 60.
(Gunawan & Karimah, 2017)	Question-naires, collected data	Validity and reliability tests	Multiple linear regression method hypothesis	Implemented on plan	Control plan	Six sigma has also proven successful in improving quality management to zero defect failure
(Yurim Zagloel et al., 2018)	Question-naires	PLS- SEM	Convergent validity, Discriminant validity, Composite Reliability	Implementation model	The evaluation of structural model	The results of this study indicate that a critical success factors that has a positive impact
(Yuliyono et al., 2019)	Collected data required	Sigma level (before)	Fishbone diagram, root cause hypothesis	Made including adding indexes to the database tables, number of tax return processed	Control phase, Sigma level (after)	Improvement exposes, the average value of six sigma significantly escalated by 0.97 to 2.56
(Primandaru & Soeparno, 2019)	Project charter, Mapping of the process	CTQ DPMO Sigma level	Root cause	Validate improvements Reevaluate the impact of solutions	Implement process control plans	Companies solve a problem that candisrupt business processes
(Ridwan & Noche, 2018)	SIPOC, CTQ VoC, VoB	Weibull analysis	Pareto, Ishikawa diagram	FMEA	Process control system	These metrics are utilized to eliminate 'waste' in the cargo-handling process at ports.
(Valdi et al., 2019)	CTQ, Map analysis SIPOC	DPMO value Sigma level	Fishbone Diagram,	5W+1H, Six Sigma level	DPMO and Sigma Value Calculation Program	The quality of data and the quality of human resources can be balanced.
(Kartika et al., 2020)	The product moment correlation analysis technique Variable six sigma determine	The product moment correlation analysis technique Variable six sigma measure, sigma level	The product moment correlation analysis technique Sigma level	The product moment correlation analysis technique Variable six sigma improve, sigma level	The product moment correlation analysis technique Variable six sigma control Sigma level	The Six Sigma method has a positive and significant effect on pharmaceutical industry performance.
(Tirtaningrum & Ernawati, 2023)	Check Sheet SIPOC, Histogram	Pareto Diagram P-chart, Control chart, Sigma level	Ishikawa diagram	5W+1H, CTQ	Control plan	can improve the quality of service in delivery and maintain customer trust

The application of the Six Sigma method in an organization by the D-M-A-I-C steps. Some tools used in the Six Sigma method in the manucfacturing industry include: (1) Define Step: data collection, VoC, VoB, SIPOC, (2) Measure Step: process capability, sigma level, PLS-SEM, (3) Analyze Step: pareto diagram, fishbone diagram, FMEA, (4) Improve Step: corrective action, redesign, design of experiment DoE, FMEA, technical training, risk analysis, 5W+1H, (5) Control Step: standardization, control plan, standard

operating procedure SOP, statistical process control SPC. The majority of the authors in this project Six Sigma in manufacturing sector have reached a common point of view concerning the application of the DMAIC pattern.

The list of journals and conferences of Six Sigma approach in manufacturing sectors represented in the sample is available on Table 1, allowing to identify a list of addressed topics: from efficiency to effectiveness (Adriyanti & Vanany, 2019); productivity (Rofiudin & Santoso, 2018); design (Lukitaputri et al., 2015); innovation (Valdi et al., 2019), (Ridwan & Noche, 2018); quality control (Access & Sinaga, 2017), (Rimawan et al., 2019). The research and variables as shown in Figure 4.

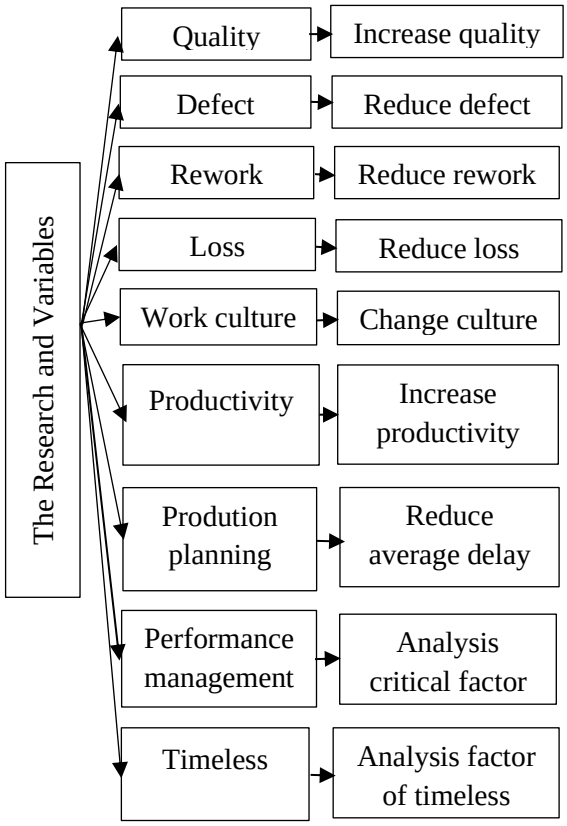

Figure 4. The research and variables

The Figure 4 shows that the research on Six Sigma in manufacturing and services sectors have some variables. Quality improvement is most variable on research in Six Sigma method. In making an improvement, the company need tools that they can use according to the needs of their own company. By applying suitable tools, it will benefit the company both from the time needed to make a process improvement, up to the cost benefits.

The Six Sigma goal of making improvements: reducing the cost of rework or repair (Syafwiratama et al., 2017), (Shonhadji, 2017); reducing the cost of improving productivity (Saryanto et al., 2020); growing market share (Trimarjoko et al., 2019); reducing cycle times (Primandaru & Soeparno, 2019); customer retention (Rawendra & Puspita, 2020); minimize defects (Gunawan & Karimah, 2017); changes in work culture (Yurim Zagloel et al., 2018); develop service products (Putri et al., 2018).

4. CONCLUSION

The literature review has highlighted of Six Sigma approach in manufacturing and services industries in Indonesia which are represented by the research analyzed manuscripts in the form of journals and proceedings. The results of this study show that the method Six Sigma has a positive and essential effect on the efficiency in manufacturing and services industries in Indonesia. The steps in implementing the Six Sigma method in each industrial sector are the same, namely DMAIC. Tools of the Six Sigma method difficult to introduce a full DMAIC pattern in services industries to boost efficiency. In the service industry to measure performance such as timeliness and lead time is more important. The critical characteristics and success indicators of Six Sigma projects in the service sector are sometimes related to behaviour and people's skills. Approachability and time reduction are the performances of the service sector in particular. The instruments used in the service industry can vary from the tools used in the manufacturing sector. In manufacturing sectors usually take on staffs that have a more mathematical and statistical backgrounds like engineers. Basic tools for brainstorming such as Pareto analysis and cause-effect analysis are definitely used in both industries.The performance indicators for Six Sigma projects can be different from the manufacturing ones. Practitioners and academics should also investigate what kind of tools inside the DMAIC pattern can be used for different types of service sectors.

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