Reveal Six Sigma Implementations in Indonesia Manufacturing Industries

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Abstract

Six sigma as a proven improvement methodology has been widely used among organizations in various industries. It focuses on improving production processes, reducing variation, and eliminating waste leading to higher efficiency and profitability. Six sigma has been applied in Indonesian manufacturing industries and continues to grow. This paper discussed six sigma implementations in Indonesian manufacturing industries that identifies sigma levels from various manufacturing sectors and summarizes current evidence that contributes to revealing the current sigma level. This study reviews six sigma project cases from one of six sigma consulting firms in Indonesia. Six sigma project cases were collected from 2019-2022, the total project cases during that period included 120 six sigma project, and 58 projects that meet the criteria has been selected for this study. The results show that from 58 selected projects, the average sigma value of the observed industries was 3.7 before improvement and 4.1 after improvement. However, the highest sigma level before improvement was 4.8 which came from fast moving consumer goods (FMCG) sector and the highest sigma level after improvement was 5.4 which came from the packaging sector.

Keywords
Six Sigma, Improvement, Manufacturing, Industry, Quality.

1. Introduction
Six sigma first introduce 1987 in Motorola by Bill Smith for project improvement (Antony et al. 2017). Implementation of six sigma is broadly used as a guideline for making better quality products and decreasing manufacturing process variation (Tjahjono et al. 2010; Herlambang 2020). Six sigma as a quality improvement method widely used by organizations because six sigma very popular in industrial sectors for quality improvement initiatives (Smętkowska and Mrugalska 2018; Utomo 2020; Singh and Rathi 2020). In Indonesia, six sigma has been implemented in many manufacturing sectors, like automotive, heavy industry, food and beverage, petrochemical, oil and gas, and small-medium enterprises (Widjajanto and Purba 2021).

This paper was created with the background of seeing the sigma level in the Indonesian manufacturing company. Project quality improvement cases were collected from one of the training and consulting firms in Indonesia that focus on helping many companies and professionals in implementing six sigma. This firm has helped many companies implement six sigma through training and consulting programs. This research aims of seeing the actual sigma level in the manufacturing sector in Indonesia by measuring and transforming the quality improvement project into a sigma level.

2. Literature Review

General Electric and Motorola are two well-known and larges companies that have successfully implemented six sigma (Hekmatpanah et al. 2008). Motorola used six sigma to reduce defects, produce higher quality products, and increase customer satisfaction at a lower cost (Mikel Harry and Schroeder 2000). The reason Motorola developed six sigma was to compete with Toyota, which at that time had succeeded in developing Toyota Production System (TPS) (Mikel Harry and Schroeder 2000; Antony et al. 2017). Six sigma as a business excellence strategy became popular in 1995 when it was implemented in General Electric by Jack Welch (Parmar and Desai 2020). Six sigma has been popular among industries because it is known as business improvement approach that aims to reduce defects in business processes by focusing on better outputs that improve customers satisfaction (Albliwi et al. 2015; Hekmatpanah et al 2008; Walter 2018). This methodology has been used to reduce defect, leading to production cost reduction, improve company profits, increase customer satisfaction and productivity (Raval et al. 2020; Winatie et al. 2020).

Six sigma has been considered as a metric, a methodology, and a management system (McCarty et al. 2004). Six sigma as a metric is useful for measuring process variation to measure quality and measuring improvements made. As a metric it used by organizations to measure level of quality. This is because sigma is a standard that can represent the degree of control of each process to meet the standards that have been set. A process that meets at the 6 Sigma level as a measurement scale is operating at a 99.99966% quality level (McCarty et al. 2004). Six sigma as a methodology built on the six-sigma metric. Six sigma uses the DMAIC method to analyze processes to reduce sources of variation that exceed tolerances and provide alternatives to reduce defects and variations. Leveraging sigma metrics and combining them with DMAIC methodology, makes the six-sigma methodology become a good problem solving and good continuous improvement. Using this DMAIC methodology has helped many organizations gain significant improvements in cost, quality, and customer satisfaction (de Freitas and Costa 2017). Six sigma as a management system is used to improve business in four main areas, namely managing customers, managing business processes, minimizing variations, and encouraging rapid business development processes (McCarty et al. 2004). The aim of the six sigma initiative is to reduce costs of quality (COQ), e.g. rejection, rework, scrap inspection and warranty costs, which is estimated to be 10-15% of the general COQ (Murumkar et al. 2018).

Six sigma DMAIC has five-phase that define, measure, analyze, improvement, and control methods to solve the problem (Pyzdek 2009; Brady and Allen 2006). Define is a phase to determine the objectives of improvement activities. Measurement is a phase to measure the performance of a system. Analyze is a phase to identify the cause of the problem. Improvement is a phase to carry out system improvement based on the problem found in the analysis phase. Control is a phase to control the results of the improvements that have been made so that it becomes the latest form of the system (Pyzdek 2009).

The goal of six sigma is 3.4 defects per million opportunities later called DPMO for each process (Linderman et al. 2003). This goal was far from normal quality levels and need a huge effort. Achieved 6 sigma level means only 3.4 DPMO and 99.99966% process yield with computations assuming a 1.5 standard deviation shift within the process mean (Linderman et al. 2003). Yield is the ratio of the total defect-free units delivered to the customer over the total number of units that entered the system. Defect per million opportunities will count all types of defects in a system (Verma 2003). The following Formula 1 is a formula to calculate DPMO (McCarty et al. 2004):

$$DPMO = \frac{Defect \times 1\ Million}{Units \times Opportunities} \quad (1)$$

Sigma level can be calculated by transforming the measured value from the DPMO, based on the following in Formula 2 (Arcidiacono and Nuzzi 2017). To calculate the sigma level just put this formula in excel.

$$Sigma\ Level\ Nrmsinv(\frac{1000000-DPMO}{1000000}) + 1.5 \quad (2)$$

There are two ways to obtain the sigma value, namely calculating with Formula 2 and looking at the sigma value at the six-sigma conversion table as in Table 1. For example, 32 DPMO in the conversion table is equal to a 5.5 sigma value.

Table 1. Six sigma conversion table
Source: (McCarty et al. 2004)

Defects Per Million (DPMO)	Sigma Level	Defects Per Million (DPMO)	Sigma Level	Defects Per Million (DPMO)	Sigma Level
3.4	6.0	1350	4.5	66807	3
5.4	5.9	1866	4.4	80757	2.9
8.5	5.8	2555	4.3	96801	2.8
13	5.7	3467	4.2	115070	2.7
21	5.6	4661	4.1	135666	2.6
32	5.5	6210	4	158655	2.5
48	5.4	8198	3.9	184060	2.4
72	5.3	10724	3.8	241964	2.2
109	5.2	13903	3.7	274253	2.1
159	5.1	17864	3.6	308538	2
233	5	22750	3.5	344578	1.9
337	4.9	28716	3.4	382089	1.8
483	4.8	35930	3.3	420740	1.7
687	4.7	44565	3.2	460172	1.6
968	4.6	54799	3.1	500000	1.5

3. Methodology

This study aims to look deeper into the application of six sigma in various manufacturing sectors in Indonesia. This research was conducted using database from one of the training and consulting firm in Indonesia who work on helping client implementing six sigma initiatives. The database was collected from the client and participants who carry out lean six sigma project improvement in their company. Prior conducting the six-sigma project, during the training session, all participant who carry out improvement projects with the six sigma or lean six sigma method has already been informed that in each project there should be use DPMO and sigma value calculation before and after improvement. Sigma level of each project must be measured instead of percentage. The research method can be seen in Figure 1. The first step in this study is to collect improvement project case data which employed the six sigma DMAIC methodology. Total data included 120 improvement projects. The second step carry out by selecting cases that are related to quality improvement, specifically utilizing attribute (discrete) data, for example, cases: reduce biscuit defect rate, reduce wafer defect, reduce garment rejection, etc. Project improvement with continuous data was excluded.

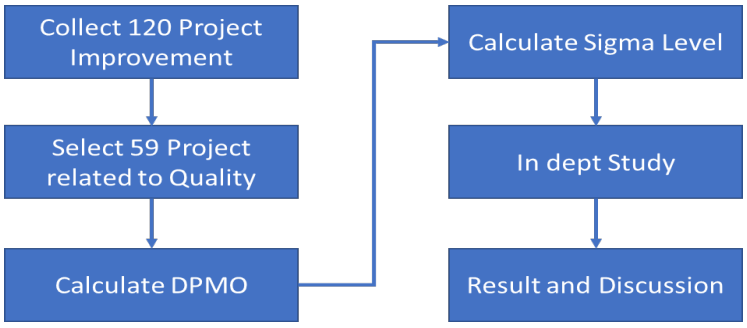

Figure 1. Research methodology

The reason to use only attribute data in this study is to make sure DPMO and six sigma level calculation process follow the same procedure by utilizing the same formula (Formula 1 and Formula 2) since formula for continuous data is different. Attribute data consist of classifications rather than measurements (Pyzdek 2003). The last selection criteria are that the project must described the critical to quality (CTQ) of each product clearly. Defect type of their product as criteria for quality acceptance must be clear since it is the base criterion for DPMO calculation. Based on those criteria there were 59 projects have been selected. The third step is to calculate the DPMO value, even though most of the projects already have their own DPMO information, however, the author then checks again the formula and the defect number in their calculation. Step four calculates the sigma value based on the DPMO value obtained in the previous step. There are two ways to calculate the sigma value, namely calculating by employing Formula 2 and looking at the sigma value from the sigma conversion table in Table 1.

Step five conduct in-depth study for 59 selected projects. In this step, author grouping the company based on the company's sector, some cases engaged in FMCG, automotive, metal fabrication, pharmaceutical, flavor, garment or textile, packaging, pulp, and paper, etc. Detailed data for this study described in Figure 2. To analyze the data simple statistic was employed to calculate minimum, average, and maximum sigma values. The final step is the result and discussion, data visual prepared by excel graphs in seeing the sector with the highest sigma value. Then authors classify sigma value before and after making improvements for each sector.

4. Result and Discussion

Based on the 59 selected projects, the authors classify these projects into 16 types of manufacturing industry, project data described in Figure 2. The FMCG industry is the most dominant with 13 projects. The automotive with 11 projects. The metal fabrication industry and the pharmaceutical industry each have 4 projects, the garment & textile industry, the packaging industry, the pulp & paper industry, and the stationery industry (ink and pencils) each have 3 projects. The building material industry, the electronic industry, the feed mill industry, the rubber industry, and the shoe industry each have 2 projects. In addition, there are poultry and plastic bottle industries that have 1 project for each.

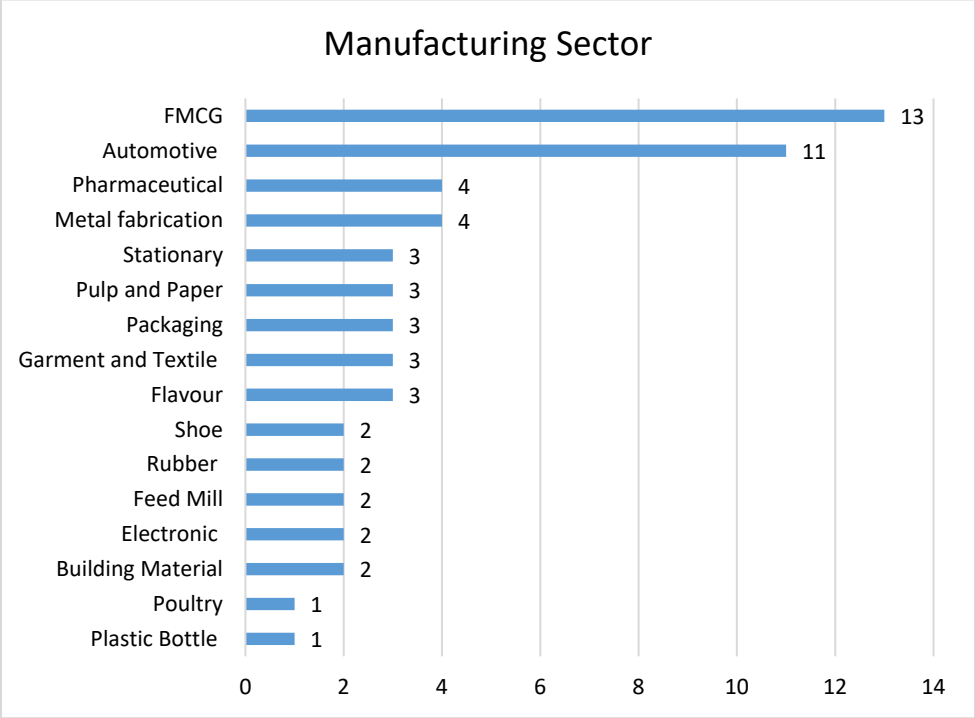

Figure 2. Improvement project case

Based on the collected data, statistically, it revealed that the lowest sigma value before improvement for all sectors was 2.5 which is from the feed mill sector, the maximum value obtained was 4.8 which came from FMCG, and packaging sector and the average sigma value was 3.7 as described in Figure 3. While after improvement it appears that the sigma value is getting increased. After improvement, it revealed the lowest sigma value 3.1 which came from the fed mill sector, and the highest sigma value obtained 5.4 which came from the pharmaceutical and FMCG sectors. If we compare the overall industry sector, there is an improvement in sigma value on average from 3.7 to 4.1 there is an increment in sigma value about 0.4 sigma or a 10% improvement in average. This improvement was achieved by carrying out several activities that improve process performance by utilizing six sigma tools and DMAIC methodology.

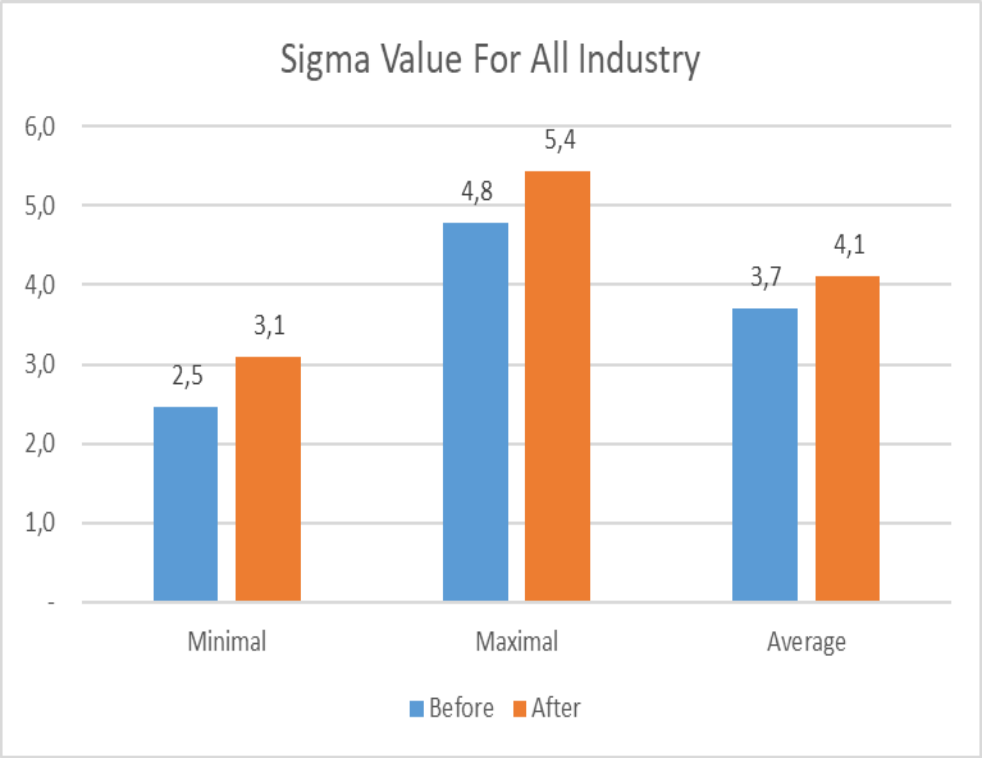

Figure 3. Sigma value before and after improvement for all sector

Compare to the previews study by (Widjajanto and Purba 2021), their study method used a literature review data of six sigma implementation in Indonesia, six sigma value of the observed industries is 3.68 on average while this study has an average value of 3.71 before improvement and 4.1 after improvement. The highest sigma value in their study was 5.10 obtained from the bagging process of a sugar refinery, while this study revealed a maximum value of 4.8 before improvement and 5.4 after improvement. What we can see from both study the average value for sigma levels is close to each other. The data for this study also revealed that the most significant improvement in terms of sigma value was 1.9 which come from the packaging sector where the value before improvement in this sector was 3.5 and after improvement was 5.4, which is about 60% increments in sigma value. (Figure 3)

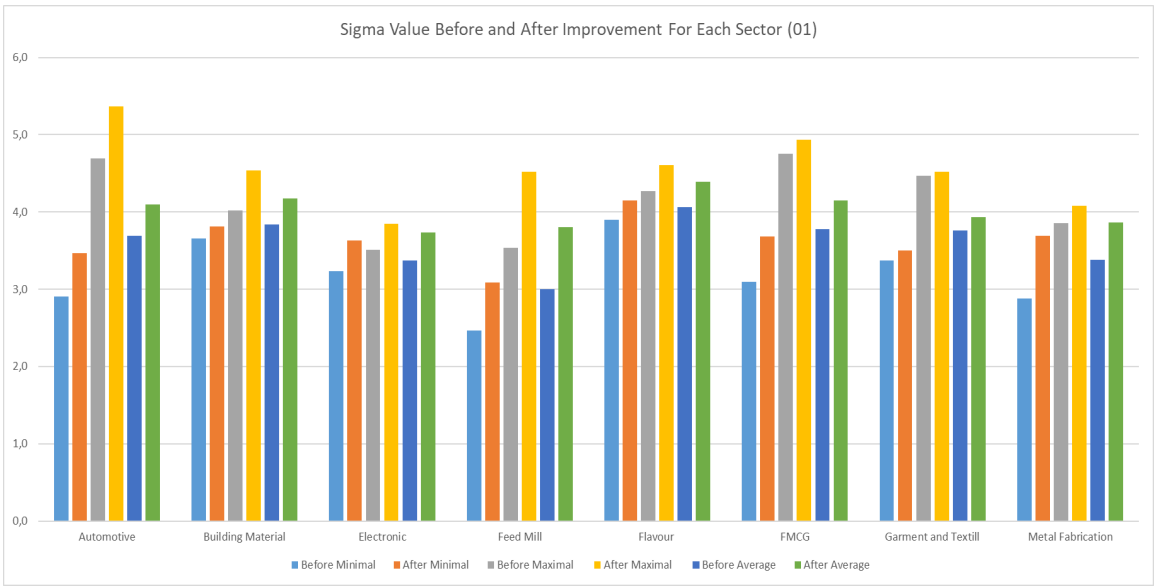

Figure 4.A. Sigma value before and after improvement for each sector (1)

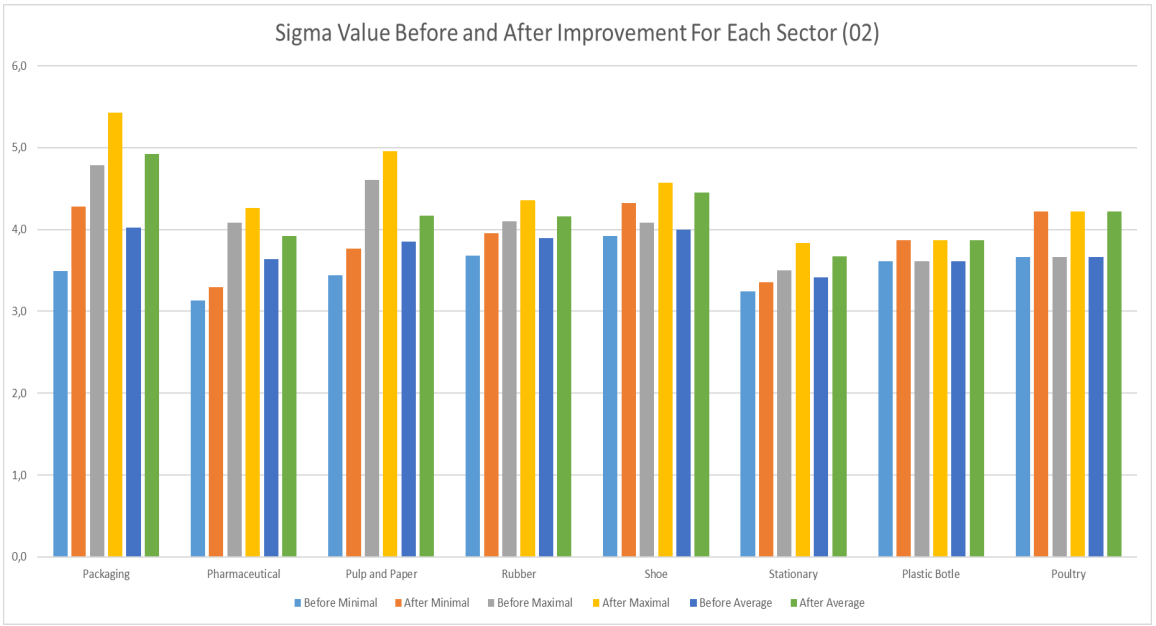

Figure 4.B. Sigma value before and after improvement for each sector (2)

Data in Figure 4.A and 4.B show sigma values before and after improvement for each sector. It appears that average sigma value increased in all sectors based on this data. Data of this study show that the average reject in terms of percentage of 9.53% before improvement and 3.84% after improvement. This result correlate with the increments of sigma value from 3.7 to 4.1 before and after improvement. It is confirmed that the six sigma initiative will bring better results, increase sigma value hence will reduce defects (Murumkar et al. 2018; Husen et al. 2021). This result also confirm with the previous study on six sigma initiatives that six sigma affected quality (Omoush 2020).

5. Conclusions and Future Research

This study reveals sigma value for various manufacturing sector based on an improvement project case study in Indonesia, in total 16 manufacturing sector has been studied. The average sigma value for all sectors in this study was 3.7 before improvement and 4.1 after improvement, there is increment 10%. This shows that six sigma initiatives bring better process performance. Increased sigma value will reduce the defect hence cost of poor quality (COPQ) will be reduced. Reducing the COPQ can be a gold mine for companies. Systematic application of the six sigma DMAIC methodology in manufacturing will help companies bring down the cost of quality and increase profit (Murumkar et al. 2018). The highest sigma value obtained in this study was 5.4, still below 6 sigma, this still needs radical improvement to achieve a better result. After a deep investigation of the case study, it appears that utilization of six sigma tools not yet maximized. Most of the the tools being employed in the project is the simple tools. Utilization of advance tools is still required for example the application of design of experiment (DOE) for quality improvement, since none of the project case study employs this powerful tool.

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Biographies

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