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USING SIX SIGMA TO IMPROVE CUSTOMER LIFETIME VALUE: A CASE STUDY

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ABSTRACT

This research examines the potential role of Six Sigma methodology as a strategic tool for enhancing Customer Lifetime Value (CLV) through cost optimization. A case study was conducted at El Nourasi Corporation, a ceramic tile manufacturer in Algeria, the study employs the DMAIC framework along with Failure Mode and Effects Analysis (FMEA) to identify production inefficiencies that inflate unit costs. Based on twelve months of production data from 2021, the analysis revealed that low average daily output led to a high per-unit fixed cost, negatively impacting profit margins and, consequently, CLV. Root causes were identified using Fishbone Diagrams and prioritized via Risk Priority Numbers (RPNs). The company significantly improved production efficiency and reduced fixed costs through targeted process improvements. These findings underscore the performance-enhancing nature of Six Sigma and emphasise its potential to enhance CLV through internal operational improvements rather than customer-side strategies alone.

1. INTRODUCTION

Fundamental changes in the market environment such as short product life cycle and high customer awareness made traditional marketing based on the 4Ps (product, price, place, and promotion) insufficient, prompting companies to shift from transactional marketing to relationship and customer-centric marketing (Fader & Hardie, 2009; Hoekstra & Huizingh, 1999). To acquire, develop, and retain profitable customers, many metrics are used that allow segmenting customers based on their profitability, and there is no doubt that the most important metric is the Customer Lifetime Value (CLV) (Venkatesan & Kumar, 2004). The concept of CLV has become a popular research topic in relationship marketing (Heitz et al., 2011). The concept of CLV has gained more significance than ever before as customer databases get bigger and there are more chances for analysis and research. This idea is crucial for customer management in general as well as for customer segmentation, selection, and retention. A growing number of research studies have focused on the CLV, which characterizes the possible return on a customer's lifespan throughout their engagement with the business (Crowder et al., 2007). Many of these studies focus on how to maximize customer lifetime value.

On the other hand, the Six Sigma methodology is a popular tool for improving processes and reducing waste by focusing on the voice of the customer (Bañuelas & Antony, 2004). Through this study, we aim to improve CLV through the cost approach instead of the revenue approach by relying on the Six Sigma methodology to improve the average daily production, which will lead to a decrease in costs due to the presence of fixed costs that are not linked to changes in production volume, which will allow increasing the gap between costs and revenues.

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2. LITERATURE REVIEW

In this section, we will try to explain the concepts of six sigma and customer lifetime value.

2.1 Six sigma

Six Sigma was developed by Motorola engineer Bill Smith in the mid-1980s. Six Sigma played a major role in the transformation Motorola made in quality at the time, which allowed the company to win the Baldrige National Quality Award in 1988 (Snee, 2010). After that, many other companies like General Electric (GE), Sony, United Signal, Johnson Controls, Texas Instruments, Polaroid, etc. also applied Six Sigma, thanks to the efforts of Jack Welch, General Electric has become the most successful company using the Six Sigma during the 1990s, within four years, GE found Six Sigma saved more than $2 billion and recorded an 11% increase in sales and a 13% increase in profits from 1996 to 1998 (Aldowaisan et al., 2015; Hakimi et al., 2018; Honda et al., 2018).

Six Sigma is seen as a philosophy, that uses continuous process improvements to reduce processes variability and eliminate waste based on statistical tools and techniques (Bañuelas & Antony, 2004), also Six Sigma is treated as a business strategy designed to identify and eliminate defects by starting from the voice of the customer (Antony, 2004), and leading to implementation, that is why it is considered as a top-down approach (Antony et al., 2012), the main purpose of Six Sigma is to get 3.4 defects per million opportunities (DPMO) or less (Pepper & Spedding, 2010; Srinivasan et al., 2016; Suryadi et al., 2017) good application of Six Sigma reducing costs, shortening project time, improving results, and increasing data probity (Tjahjono et al., 2010).

2.2 DMAIC

Kwak and Anbari (2006) indicated that DMAIC is a closed-loop process that eliminates non-productive steps, typically focuses on new statistics, and applies continuous improvement techniques. It includes the following steps:

Define: Define customer requirements, project limits, and processes by mapping business progress.

Measure: Measure the process, develop a data collection plan, and gather data to determine problems and defects.

Analyze: Analyze the causes of defects, identify process changes, and design opportunities for future improvement.

Improve: Eliminate the causes of defects by putting in an enhanced plan.

Control: Manage process variations, establish a strategy to monitor and control the new process, and implement the improvements of systems and structures.

2.3 The fishbone diagram

The fishbone diagram or Ishikawa diagram, was developed in the 1960s by Japanese quality control statistician Kaoru Ishikawa. It is a simple and effective causal analysis tool that relies on brainstorming to identify root causes and classify them into main cause categories (Shinde et al., 2018; Xu & Dang, 2020).

Although the fishbone diagram is a practical tool characterized by ease of use and collective participation of ideas, it consumes time if there are many causes and problems, and the strength of the relationship between them cannot be determined, and it is also difficult to use Ishikawa diagram in an electronic form (Bilsel & Lin, 2012).

2.4 Failure mode and effect analysis

Failure Mode and Effects Analysis (FMEA) was first declared as a method in a document by the U.S. Military in 1949. Today, FMEA is successfully applied to many other industries, not just limited to the Defence industry, like rail and subway, aerospace, automotive, engineering, Semiconductor, and Oil and Gas Industry (Anjalee et al., 2021). FMEA is a tool for identifying and eliminating known or potential errors before they occur, improving system reliability, and informing risk management decisions (Moreira et al., 2021). It is also known as an analytical technique that combines technology and human experience to identify predictable failure modes of a product or process and plan to eliminate it, FMEA is widely used in manufacturing at all stages of the product life cycle and is now increasingly used in the service industry (Kumru & Kumru, 2013).

The standard FMEA process ranks failure modes by occurrence, severity, and detection rate. Multiplying these values gives the so-called Risk Priority Number (RPN) (Carbone & Tippett, 2004; Hu et al., 2009). Error models with higher RPN values are considered more important, and corrective actions can be prioritized over lower RPN values. FMEA aims to give priority to the most important failure modes that comply with resource constraints and provide valuable information to upgrade quality (Battirola Filho et al., 2017). For project management, FMEA offers some advantages. It places a strong emphasis on preventing issues and serves as a stimulant for collaboration and constructive idea-sharing. It gathers engineering expertise and offers a focal point for better testing and development, which ultimately raises customer satisfaction (Ebrahimipour et al., 2010).

2.5 Customer lifetime value

The concept of Customer Lifetime Value has evolved significantly since its emergence in the literature, with researchers proposing many definitions that reflect its conceptual complexity and various applications in marketing and finance. These interpretations emphasise different components—such as cash flows, cost structures, and time horizons. Consequently, several expressions or typologies of Customer Lifetime Value have emerged. Kotler (1974, p. 24) defined CLV under the name Long-run Customer Profitability as: "the present value of the future profit stream expected over a given time horizon of transacting with the customer", but the first to come up with this idea was Bursk (1966) under the name Investment Value, where he indicated that customers are assets in which the company can invest.

According to Dwyer (1997, p. 7) customer lifetime value refers to "the present value of the expected benefits (e.g., gross margin) less the burdens (e.g., direct costs of servicing and communicating) from customers". Furthermore, Kumar et al. (2004, p. 61) defined Customer Lifetime Value (CLV) as "the sum of cumulated cash flows discounted using the weighted average cost of capital of a customer over his or her entire lifetime with the firm". It is important to note that in Dwyer's definition, the expected benefits can be direct and indirect, like word of mouth. Since this definition also considers only Expected benefits and costs, it ignores the past (e.g., cost of customer acquisition). Given that Kumar's definition focuses on the customer's cash flow, costs are not considered.

Companies must consider both sides of customer value when allocating resources: the value a company provides to its customers and the value customers provide to the company. These two aspects reflect the different philosophies of marketing (customer is king) and finance (cash is king) (Gupta & Lehmann, 2006).

Deferent models have been developed to estimate Customer Lifetime Value (CLV). Each of them reflects special assumptions about customer behaviour and profitability. Given the complexity nature of the CLV concept and its importance to corporate valuation, researchers have proposed both deterministic and stochastic approaches to better capture the long-term financial value of customers with both, contractual and non-contractual settings. These models range from relatively simple measurement based on historical transaction data to advanced statistical and predictive models that incorporate customer retention and churn, purchasing patterns, and discounting of future cash flows. Among the most widely used are the structural model, the Pareto/NBD model, the BG/NBD model, and the RFM model—each offering distinct advantages depending on data availability and business context (Berger & Nasr, 1998; Schmittlein et al., 1987; Fader et al., 2005; Cheng & Chen, 2009).

The structural model: Presented by Berger and Nasr (1998), which is also attributed to Jain and Singh (2002), and the mathematical expression for this model is:

$$CLV = \sum_{i=1}^{n} \frac{(R_i - C_i)}{(1+d)^{i-0,5}}$$

In the formula, i is the period when customers bring cash flow; Ri is the company's revenue brought by customers in period t; Ci is the total cost incurred to generate revenues Ri; Ri- Ci is the profit of these tested customers during relationship period; n is the life cycle of the customer; d is the discount rate.

Pareto/NBD model: The Pareto/Negative Binomial Distribution model was developed by Schmittlein et al. (1987). The model utilizes observed past buying behaviour of customers to predict future buying behaviour, and this result is then used as an input to estimate customer lifetime value.

BG/NBD model: this model (the Beta-Geometric/Negative Binomial Distribution) was developed by Fader et al. (2005). It is similar to the Pareto/NBD model, but what distinguishes it is the ease of obtaining its parameters through Microsoft Excel.

RFM model: According to Cheng and Chen (2009), the RFM model was first proposed by Hughes from the American Database Institute in 1994 as a popular tool for customer value analysis. It has been widely used in customer segmentation and behaviour analysis through sales database mining. RFM is an abbreviation for recency, frequency, and monetary value, which refers to the recency of the last purchase, the frequency of purchase, and the monetary value of the purchase, respectively.

3. METHODOLOGY

This study employs a quantitative case study approach to examine how Six Sigma methodologies can be used to improve Customer Lifetime Value (CLV) by reducing fixed costs through enhanced production efficiency. The study was carried out at El Nourasi Corporation, an Algerian ceramic tile manufacturer, which produces various formats of ceramic floor and wall tiles.

The study builds on the **DMAIC framework**—Define, Measure, Analyze, Improve, and Control—as a systematic method to problem-solving central to the Six Sigma philosophy. The objective is to identify process inefficiencies that result in high production costs and propose specific improvements to enhance daily production output, thereby reducing fixed costs per-unit.

3.1 Data collection

The main source of data, obtained from the company's production database, provided the average daily production records from January 2021 to December 2021. These records contained the daily output quantities for various tile formats. Expert consultations with production engineers were conducted to determine the specification limits for each tile format and evaluate operational constraints.

In order to quantify the financial impact of production inefficiencies, cost information related to fixed daily expenses, including salaries and utility costs (such as electricity used for administrative services and the fixed part of the gas costs that keep the kiln operating all year long), was collected alongside production data.

3.2 Application of the DMAIC Approach

Each phase of DMAIC was systematically implemented as follows:

Define: The objective was to address reduced average daily production, which increases unit fixed costs and negatively impacts CLV.

Measure: Production records from 2021 were collected. Specification limits and target values were determined by production experts. Descriptive statistics were then

calculated to assess the process's variability and determine if it is within the defined specification limits.
Analyse: The Fishbone Diagram was employed to identify potential root causes, and FMEA (Failure Mode and Effects Analysis) was applied to prioritize risks according to their severity, occurrence, and detection.
Improve: Improvement strategies focused on the most critical failure modes identified in the analysis phase.
Control: In this phase, measures and solutions were suggested to sustain the improvements, including preventive maintenance, suitable suppliers, and workforce accountability systems.

3.3 Estimating Impact on Fixed Costs and CLV

In order to assess the financial effect of process improvements, fixed costs per unit were calculated both before and after implementing suggested improvements. The following formula was used:

$$Fixed\ Cost\ per\ m^2 = \frac{Total\ Daily\ FC}{Average\ DP\ (m^2)}$$

Where FC is fixed costs and DP is daily production

The projected increase in Customer Lifetime Value after process optimization was then computed by applying the difference in fixed cost per square meter to the customer-level purchase quantity Q.

4. RESULTS

The results of the research are displayed according to the stages of the DMAIC approach as follows:

4.1 Define

The problem was defined as a persistent decrease in the average daily production, which was inflating the cost per square meter due to the high proportion of fixed costs in total production cost. The objective was to raise the production capacity to reduce the cost of producing one unit, which leads to a decrease in costs Ci and thus an increase in the gap between the revenues obtained from the customer Ri and costs Ci, and thus increasing customer lifetime value, which is calculated according to the following equation:

$$CLV = \sum_{i=1}^{n} \frac{(R_i - C_i)}{(1+d)^{i-0,5}}$$

4.2 Measure

First, we will determine the lower specification limit (LSL) and the upper specification limit (USL), and the Target for each tile format with the help of the company's production experts, as shown in Table 1.

Table 1. LSL, USL, and target for each tile format

Format (cm)	LSL (m2)	Target (m2)	USL (m2)
25x60	7.000	7.650	8.609
25x75	6.800	7.100	7.515
60x60	5.000	5.350	6.042
45x45	7.000	7.650	8.093
Average	**6.450**	**6.937,50**	**7.564,75**

Since the company produces multiple formats, we will determine New LSL, New Target, and New USL based on a percentage of annual production (PAP), as shown in Table 2.

Table 2. New LSL, New USL, and New Target

Format (cm)	PAP	New LSL (m^2)	New Target (m^2)	New USL (m^2)
25x60	31,20%	2.184	2.386,80	2.686,01
25x75	27,87%	1.895,16	1.978,77	2.094,43
60x60	20,55%	1.027,50	1.099,43	1.241,63
45x45	20,38%	1.426,60	1.559,04	1.649,35
Total	**100%**	**6 .533,26**	**7.024,07**	**7.671,42**

Table 3 shows the mean and standard deviation of daily production.

Table 3. The mean and standard deviation of daily production

Year	Mean	Standard deviation
2021	4.731,66	1.740,92
Total	**4.731,66**	**1.740,92**

To determine the Sigma level, we will use the statistical method that depends on measuring the capacity of the process from the calculation of Process Capability (Cp) and Process Capability index (Cpk) (Wu et al., 2009):

$$Cp = \frac{USL - LSL}{6\delta}$$

$$Cpk = min\left(\frac{USL-\mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right)$$

Relying on the previous two equations and the obtained data, Cp and Cpk were calculated, and the results are as follows:

Cp = 0,11
Cpk = - 0,34

The results show that Cp is less than 1, which is much lower than the minimum required level (Sigma level = 3), Also, Cpk is estimated at -0.34, which indicates a significant deviation of the process from the minimum required average production, as is confirmed by Figure 1**.**

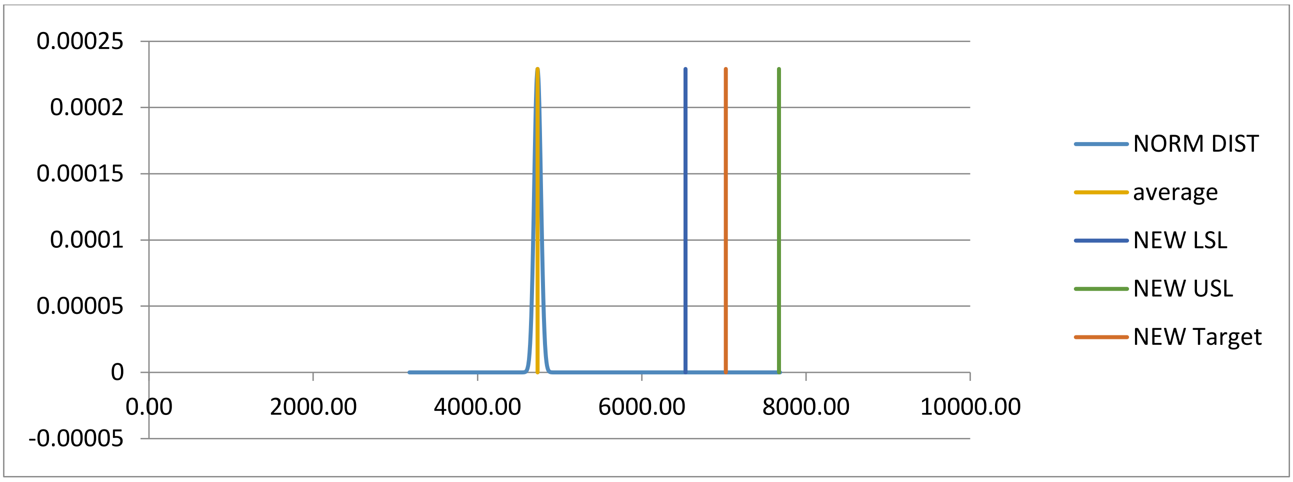

Figure 1. Normal distribution curve for average daily production for the year 2021

As shown in Figure 1, most of the points of the normal distribution curve lie outside the limits of the process and specifically to the left of the LSL.

4.3 Analyse

At this stage, we will use the fishbone diagram to determine the root causes that led to the decrease in the average daily production, as shown in Figure 2.

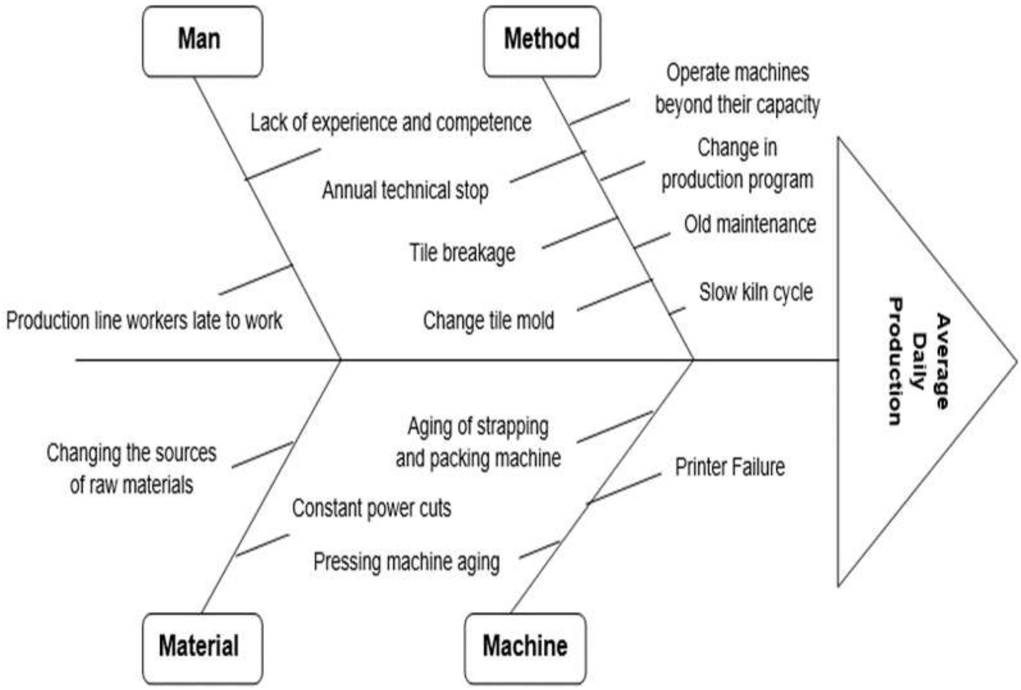

Figure 2. The fishbone diagram of the decrease in the average daily production

The next step is to do a FMEA analysis to rank the causes based on Risk Priority Number, as shown in Table 4.

Table 4. FMEA anlysis

Potential Problem	Potential Failure Mode	Severity	Occurrence	Detection	RPN
Method	Slow kiln cycle (greater than 50 min).	5	3	2	30
Machine	Aging of the strapping and packing machine.	6	4	3	72
Material	Constant power cuts.	8	8	2	128
Method	Operate machines beyond their capacity.	7	3	5	105
Machine	Pressing machine aging.	8	8	5	320
Method	Old and ill-considered maintenance methods.	8	6	6	288
Material	Continuous change in the sources of raw materials.	7	8	7	392
Man	A laborer lacking experience and competence.	8	6	6	288
Man	Production line workers are late for work.	6	4	5	120

Method	Continuous change in the production program.	5	6	5	150
Method	Adopting an annual technical stoppage instead of periodic maintenance of machines.	2	2	2	8
Method	Floor tile breakage during corrective operation.	6	8	6	288
Method	Continuously change the tile mold.	7	4	7	196
Machine	Printer failure.	5	5	6	150

4.4 Improve and control

Relying on Risk Priority Number, we will arrange the reasons in descending order, as the important reasons that require urgent intervention to be treated are the reasons that got a high RPN, and we will suggest solutions to improve and control the process, as shown in Table 5.

Table 5. Priority Improvement Proposal

Priority	Root Cause	RPN	Proposed Improvement
1	Continuous change in the sources of raw materials.	392	Assigning the laboratory research and development teams to find a suitable supplier with a guarantee of a stockpile for at least two years.
2	Pressing machine aging.	320	Comprehensive maintenance through the acquisition of various spare parts, except for the main carrier.
3	Old and ill-considered maintenance methods.	288	Develop a maintenance program consisting of preventive maintenance and emergency maintenance.
4	A laborer lacking experience and competence.	288	Employment based on professional and university certificates, while ensuring the continuous training of workers.
5	Floor tile breakage during corrective operation.	288	Continuous maintenance of grinding discs and conveyor belts, taking into account the cooling of the tiles before correcting them.
6	Continuously change the tile mold.	196	Work in the same mold for not less than 30 days.
7	Printer failure.	150	Providing good-quality ink and cleaning printer heads.
8	Continuous change in the production program.	150	Adjust the production program in line with market demand.
9	Constant power cuts.	128	Buying a gas-powered generator (due to the low gas prices).
10	Production line workers are late for work.	120	Providing the factory entrance with a fingerprint login machine with strict administrative instructions.
11	Operate machines beyond their capacity.	105	Providing other machines besides the current machines to reduce pressure on them.
12	Aging of the strapping and packing machine.	72	Purchase of a new tying machine and a small tying machine to facilitate and speed up the packaging process.
13	Slow kiln cycle (greater than 50 min).	30	Reinforcing the kiln with a special treatment area consisting of 4 burners to speed up the ripening process.
14	Adopting an annual technical stoppage instead of periodic maintenance of machines.	8	Periodic maintenance of machines at the end of each month.

4.5 Calculation of CLV after the improvement of the average daily production

First, we will calculate the total daily fixed costs as shown in Table 6.

Table 6. The total daily fixed costs

Cost Type	Average Daily Cost (Algerian Dinar)
Salaries	256.000,00
Utility costs	82.153,25
Total	338.153,25

We will divide the average daily fixed costs by the average daily production before process improvement and after process improvement (New Target) to find the difference in fixed costs before and after process improvement, as shown in Table 7.

Table 7. Fixed costs per square meter

Average Daily Cost (Algerian Dinar)	Average Daily Production (m2)	Fixed costs per square meter
338.153.25	4.731,66	71,47
338.153.25	7.024,07	48,14
The difference	2.292,41	23,32

By addressing production-related problems thanks to the adoption of Six Sigma methodology, the results showed that increasing the average daily production by 2.292,41 m^2 per day will lead to a decrease in fixed costs per square meter by 23,32 Algerian Dinar per square meter purchased by the customer, and since Q is the quantity that it is expected to purchase by customer throughout his relationship with the firm, and *New CLV* is the Customer Lifetime Value after process improvement:

$$New\ CLV = \sum_{i=1}^{n} \frac{(R_i - C_i)}{(1+d)^{i-0,5}} + 23{,}32Q$$

5. DISCUSSION

According to the findings of this study, which was carried out in a company that produces ceramic tiles, Six Sigma is a useful tool for enhancing production capacity. This, in turn, helps to lower customer service expenses because it has fixed costs that remain constant regardless of production volume, thereby enhancing Customer Lifetime Value.

It is worth noting that Six Sigma can be used to improve customer lifetime value based on the revenue approach, which is more in line with relationship marketing literature than the cost approach.

The findings of this study show the effectiveness of the Six Sigma methodology in improving production efficiency and, consequently, increasing Customer Lifetime Value (CLV) through cost reduction. By applying the DMAIC approach and conducting a detailed FMEA, the analysis found significant process inefficiencies that contributed to high production costs per square meter, mostly as a result of aging equipment, inconsistent raw material supply, and insufficient maintenance.

One of the most important insights from this study is the impact of economies of scale on CLV. Increasing the average daily production reduced the fixed cost per unit by approximately 23.32 Algerian Dinars. This cost saving contributes directly to the profit margin related to each unit sold to customers, thereby expanding the value each customer contributes over their lifetime. This result is consistent with Gupta and Lehmann's (2006) assertion that maximizing CLV involves not only managing revenues but also strategically controlling costs.

Traditionally, Customer Lifetime Value is improved by external process improvements that includes focusing on customer behavior, retention, and marketing strategies (Fader & Hardie, 2009; Venkatesan & Kumar, 2004). However, this study offers an alternative approach that emphasises internal process improvements. By reducing operational inefficiencies, companies can enhance customer lifetime value without requiring changes in customer behavior.

In addition, the use of Six Sigma tools—particularly FMEA—allowed corrective actions to be identified based on risk prioritization. In this study, for example, resolving problems such as press machine aging and inconsistent raw material supply had the greatest potential to improve production and reduce costs. These findings support existing studies that emphasise the preventative nature of the Six Sigma philosophy (Tjahjono, et al., 2010).

The current study is multifaceted in terms of limitations and future research. First, the analysis was limited to the impact of cost improvements on customer lifetime value (CLV), without considering changes in customer-level revenue or retention behavior. While this offers a new perspective, it does not provide a comprehensive framework for improving customer lifetime value. Second, the study was conducted at a single company within a specific sector and business context (El Nourasi Corporation, Algeria), which may limit the generalizability of the results. External factors, such as fluctuations in market demand, and supplier reliability, may vary significantly across different markets or sectors.

Finally, while this study focused on the potential role of reducing costs in (CLV), Six Sigma can also be applied to improving customer experience and generating revenue (such as reducing product defects or delivery delays), enhancing customer satisfaction and retention. Examining this dual approach—cost and revenue—may provide a more comprehensive strategy for improving customer lifetime value (CLV).

6. CONCLUSION

The study demonstrates that using Six Sigma—particularly the DMAIC framework and FMEA analysis—can effectively improve Customer Lifetime Value (CLV) by cost optimization instead of focusing only on revenue-based strategies. By identifying and addressing critical inefficiencies in the production process at El Nourasi Corporation, the company was able to significantly increase its average daily output, thereby reducing the fixed cost per unit. This increased profit margins and customer value. The study underscores the strategic role of Six Sigma as a driver of financial performance and customer value creation.

It also suggests that integrating cost-saving methods with revenue-based CLV models and testing them in different industries and business contexts could offer more comprehensive understanding of customer profitability.

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