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Application of Lean Six Sigma (LSS) methodology in a small-sized company that sells construction materials: a case study

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Abstract

Purpose – Service duration has a pivotal role in determining both organizational financial performance and customer satisfaction. The purpose of this study is to minimize the variation of the service time in the service procedure to avoid dissatisfaction.

Design/methodology/approach – The research develops a practical implementation of the Lean Six Sigma methodology, step-by-step, using the DMAIC methodology of define, measure, analyze, improve and control, in reducing the customers' service times.

Findings – The use of data analysis was important at various phases of the project in order to identify the root causes for the delays in customer service. The result of the method in the customer service process was a significant reduction in the service time by 27.35% and the yield was improved by 15.8%. The estimated annual savings from this project were US$ 80,000, resulting from more customers served per day and increasing returning customers.

Practical implications – This research may be used in companies that sell construction materials as a tool for managers to increase efficiency and service quality, as well as smaller companies that incorporate service. In addition, the study provided the company with helpful suggestions that will be used in future Lean Six Sigma projects. Thus, practical solutions and guidelines were provided.

Originality/value – This study addresses a significant gap in Lean Six Sigma literature by focusing on customer service within resource-constrained small- and medium-sized enterprises instead of large-scale manufacturing. By utilizing thorough statistical validation, specifically the nonparametric Mann–Whitney U test, along with data triangulation from multiple sources, the research offers context-specific, well-documented insights. It illustrates how systematic, incremental operational adjustments can yield meaningful managerial and theoretical contributions in service-centric environments.

Keywords Lean, Six sigma, DMAIC, Customer service, Pareto analysis, Process capability evaluation

Paper type Research article

1. Introduction

Small- and medium-sized enterprises (SMEs) play a pivotal role in the growth and development of global economies (Ong *et al.*, 2012). Despite their significant potential to catalyze national economic growth, SMEs are frequently susceptible to high failure rates, a phenomenon often attributed to inefficiencies within their supply chains (Paik, 2011).

The construction sector has experienced significant growth in recent years, leading to increased competition among businesses that sell these goods. Therefore, customer satisfaction has become a key factor in increasing the competitiveness of a retail business and is inextricably linked to customer service. Subsequently, a key part of customer service is the total allocated service time, as it is a key factor in choosing a business over its competitors (Garedew *et al.*, 2025; Pradhan *et al.*, 2021). Clients in the construction sector possess distinct

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expectations regarding service velocity; failure to meet these demands precipitates dissatisfaction, diminishes perceived service quality and prompts customer churn in favor of competitors. Thus, this case study will study customer satisfaction in a small enterprise selling building materials located on the island of Crete, Greece.

The primary objective of this study is to identify the factors and bottlenecks in service and to address them. Specifically, research will take place regarding the factors that affect customer dissatisfaction, evaluate their impact and propose solutions for improvement. Accordingly, in this study, the Lean Six Sigma (LSS) methodology and the DMAIC (define, measure, analyze, improve and control) framework were used to determine their effectiveness in the improvement of customer service in a small enterprise. Furthermore, this study references the identified research gap by applying the LSS DMAIC methodology to customer service in an SME with constrained resources, providing empirically validated insights with practical relevance for similar organizations that include customer service.

2. Literature review

Process optimization is inexplicably based on Lean management and SS methodologies. Usually, literature has referenced these frameworks separately, often separating the waste reduction of Lean and the minimization of variance, which is one of the fundamentals of SS (Deshmukh *et al.*, 2022; Patel and Patel, 2021). However, contemporary organizational theories suggest that treating these paradigms as mutually exclusive limits their operational potential. The integration of both philosophies into LSS provides a synergistic theoretical model that addresses both qualitative consistency and operational velocity (Ivanova and Szalla, 2025). The transition toward this integrated model indicates a shift from rigid, single-purpose methodologies to holistic management philosophies capable of aligning strategic imperatives with daily operational execution (Antony *et al.*, 2025; Ghasemibojd *et al.*, 2025).

Six Sigma with the use of the DMAIC framework, introduces a rigorous, data-centric architecture designed to preemptively identify latent defects (Panayiotou *et al.*, 2022; Prashar, 2020; Tsarouhas, 2021). From a theoretical standpoint, the effectiveness of DMAIC relies heavily on organizational maturity, structured problem solving and resource availability (Jin *et al.*, 2024). Consequently, the majority of existing empirical studies demonstrate quantifiable improvements predominantly within highly formalized environments such as aerospace, heavy manufacturing and large-scale healthcare institutions (Shamsuzzaman *et al.*, 2018; Noronha *et al.*, 2022; Niñerola *et al.*, 2020; Bhat *et al.*, 2025; McDermott *et al.*, 2024). In these resource abundant settings, the methodology thrives because the structural prerequisites, such as dedicated continuous improvement teams and advanced data tracking systems, are already established, leading to documented improvements in service delivery standards and waiting times (Garedew *et al.*, 2025; Chang *et al.*, 2020; Sharma *et al.*, 2024; Liu *et al.*, 2022; Pradhan *et al.*, 2021; Adeodu *et al.*, 2023; Gomaa, 2026; Peter *et al.*, 2023).

Conversely, the application of LSS within small- and medium-sized enterprises presents a distinct theoretical challenge. Literature highlights a fundamental tension between the demanding structural requirements of LSS and the inherent resource constraints of smaller enterprises (Arcidiacono *et al.*, 2025; Taha Kandil, 2026; Singh and Rathi, 2021). While some researchers argue for the universal scalability of these methodologies (Yadav and Gahlot, 2022), a more critical examination reveals systemic barriers including technical expertise deficits and an absence of formal procedural structures (Gaikwad *et al.*, 2020). This tension showcases that the issue of adapting LSS in an SME environment cannot be replicated directly from the methodology applied in bigger enterprises; on the contrary, the adaptation requires a distinct structure in order to incorporate resource scarcity, organizational agility and the acknowledgement of barriers like organizational culture (Gijo and Antony, 2013; Kumar *et al.*, 2015; Arora *et al.*, 2023; Flor *et al.*, 2020; Noronha *et al.*, 2023; Praharsi *et al.*, 2021).

Furthermore, the existing literature exhibits a pronounced thematic bias toward manufacturing throughput and physical product quality; frequently marginalizing customer service dimensions (Thakur *et al.*, 2024; Kashyap *et al.*, 2024). Although the DMAIC framework is increasingly associated with superior customer satisfaction outcomes (Jiménez-Delgado *et al.*, 2024; Wankhede *et al.*, 2025), this correlation is often posited axiomatically rather than empirically verified within service-oriented contexts (Srijithesh *et al.*, 2025; Kumar and Kansara, 2018; Tsarouhas and Sidiropoulou, 2024). Particularly in the construction materials sector, research remains disproportionately focused on macro-level project management or production tiers, leaving a critical gap regarding customer interfacing functions (Skalli *et al.*, 2025; Rajani *et al.*, 2022; Shahin *et al.*, 2024; Elmarzouki and Jiuhe, 2026).

A critical synthesis of this evidence base reveals a precise, unresolved research gap: while the theoretical mechanisms of LSS and DMAIC are well documented in resource-rich, manufacturing-centric environments, their analytical translation to resource-constrained and service-oriented businesses remains underdeveloped. Small enterprises within the construction materials sector operate at a unique intersection of product-based logistics and service-based interactions, creating operational complexities that existing theoretical models do not adequately capture. Addressing this gap necessitates a rigorous empirical evaluation of how these methods can be systematically adapted and what implementation mechanisms drive their success.

To investigate this research gap in depth, this study is structured around three central research questions. The first research question (*RQ1*) investigates in what manner the LSS framework can be systematically adapted and utilized within the specific context of a small- and medium-sized enterprise. The second research question (*RQ2*) explores the primary implementation barriers and critical success factors required for LSS to be integrated into the customer service process of such an organization. Finally, the third research question (*RQ3*) examines what quantifiable enhancements are attainable through the rigorous application of the DMAIC methodology regarding the service process. Thus, the present article seeks to improve quality management by using LSS DMAIC to showcase the benefits that can be gained by this method in a small company that sells construction materials.

3. Methodology

The methodological framework employed in this research is the LSS DMAIC approach. Selected for its inherent practicality and adaptability to complex operational challenges, this method integrates qualitative and quantitative tools to address organizational dynamics effectively (Francescatto *et al.*, 2023). Specifically, the case study strategy is chosen as it provides a deep understanding of the phenomenon under consideration for which SS is used, as it examines specific problems in the organization (Bhat *et al.*, 2023). In addition, case studies provide greater flexibility in both application and design compared to measurement methods, which makes them more suitable for real-life problems (Gijo *et al.*, 2019). A primary advantage of this approach lies in its capacity for data integration and adaptability, particularly in instances where the boundaries between the investigated phenomenon and its context remain indistinct (Vazquez Hernandez and Elizondo Rojas, 2024).

To ensure the transparency and the credibility of the method used, the role of the academic researchers in the case study was defined as that of external observers and consultants of the methodology rather than active participants in the processes. The researchers' involvement was focused on guiding the LSS team through the application of the DMAIC phases, the analysis of statistics and the adherence to the methodology. By maintaining an external, passive stance during the daily service operations, the researchers minimized participatory bias. During the observation procedures, the researchers acted exclusively as passive observers, systematically recording data based on predefined temporal markers without interacting with the customers or influencing the staff's standard operating procedures. This clear delineation of roles ensured that the observed improvements were the direct result of the implemented structural changes and the staff's adoption of the new protocols, rather than a temporary change in behavior caused by the external researchers' presence.

Although this research utilizes the LSS method, several alternative analytical paradigms and methodologies could be utilized to address similar operational inefficiencies. For instance, discrete event simulation facilitates the rigorous analysis and modeling of service processes (Gharehbaghi *et al.*, 2025), while queuing theory provides a robust basis for evaluating systemic capacity and wait times (Zhao and Gilbert, 2025). Furthermore, mathematical optimization techniques, i.e. linear programming, offer unique mechanisms for the refinement of resource allocation (de lima *et al.*, 2025). Additionally, regression-based and advanced statistical modeling enable predictive forecasting and the empirical assessment of service durations. Despite the merits of these specialized techniques, LSS was prioritized for its process-oriented, comprehensive structure and its alignment with the requirements and needs of SMEs. In such organizations, the interpretability of findings and operational feasibility are of paramount importance.

Crucially, the Six Sigma (SS) framework operates on a sequential basis, where each phase generates the prerequisite empirical evidence required to advance to the subsequent stage. Consequently, selected improvement projects must align organizational growth objectives with customer satisfaction requirements, ensuring a distinct correlation between operational efficiency and service quality. In this case study, the data collected refers to the time in minutes that the customer spent in each service section. Table 1 also describes the activities and tools that will be used in the SS DMAIC method for the waiting time, as will be mentioned in the following sections.

The data that was examined was time, in minutes, that is required for a customer to be served from their arrival to their departure. The time was also recorded for each service point individually, the order level and the service area, as well as the period of the day that the customer visited the store. Specifically, primary data were retrieved from the registration logs of the Enterprise Resource Planning (ERP) system, supplemented by historical ERP records to ensure objective and direct documentation.

The dataset underwent a filtration process to ensure temporal precision, which involved excluding instances where processing durations were disproportionate to order volume, as well as omitting orders related to backorders. In order to properly utilize the triangulation of data, three independent sources were systematically cross-referenced. Specifically, the main timestamps that were extracted from the ERP system were compared with the onsite observations as recorded by the research team and subsequently validated by utilizing the

Table 1. DMAIC activities for the customer service time

Define	Measure	Analyze	Improve	Control
Presentation of the purpose of the analysis	Data collection plan	Initial data collection	Defining corrective actions for improvement	Confirmation of results and establishment of improvements
Justification of the control point that will be analyzed	Presentation of the tools that will be used	Cause and effect diagram	Selecting the optimal solution	Solutions for continuous improvement
Overview of the process	Justification of the used tools	Determining the causes that lead to delays	Repetition of the process with new measurements	Ways to monitor improvement
Start of the project	Measurement checks		Presentation of the results	Control chart
Pareto cnalysis			Presentation of rejected solutions	Dot plot
Duration: 2 weeks	Duration: 3 weeks	Duration: 5 weeks	Duration: 3 weeks	Duration: 2 weeks

Source(s): Authors' own creation

audiovisual monitoring footage. This multi-source verification ensured that any discrepancies between the digital logs and the physical service execution were resolved accurately. Furthermore, to minimize potential observer bias, strict standardization criteria were established prior to data collection, defining exact physiological and transactional markers for the commencement and conclusion of each service phase. The researchers operated unobtrusively, and the staff was habituated to the presence of the cameras and observers, thereby mitigating the Hawthorne effect. Additionally, independent cross-checking of a random data subset by a second researcher was conducted to confirm the reliability of the recorded times. Consequently, the resulting dataset exhibits high accuracy and provides a robust foundation for the analysis.

In more detail, the ERP system that the company uses provides the ability to register documents with the registration time presented. In addition, two documents are registered for each customer: the order and the final. Furthermore, based on the available notes of the order form, it can be observed which of the two warehouses the customer visited or whether they visited both warehouses. In addition, regarding the waiting time before receiving the products and the waiting time for receiving the products after payment, security cameras and live observation were used. Thus, the data collection process began in December 2024, at the company's premises, with the first step being the extraction of historical data for the last three months, and then recordings were made with the Microsoft Excel software in real time, which combined with the historical observations to form the final data and calculate the service time of each customer, while the total sample was 200 customers. In order to better represent the data, the selection of the 200 observations was guided primarily by the need to accurately represent the variance of the service process across different conditions. A structured sampling strategy was therefore applied, with observations systematically distributed across different days of the week, peak and off-peak operational hours and varying order complexities, including single-warehouse and mixed-warehouse orders. These criteria were selected because service time could vary according to customer traffic and the operational complexity of each order. The resulting sample therefore captured observations from the principal operating conditions encountered during the data-collection period rather than concentrating on a single day, time period or order type. This structured approach was intended to reduce temporal and operational selection bias and to improve the representativeness of the dataset with respect to the service conditions examined in the case study. Finally, the Minitab statistical software was used for data processing, due to its extensive processing capabilities. Specifically, a regularity check will be performed on the service time of each customer to determine the normality of the population and then an I-MR control chart will be created in order to ascertain the stability of the process. In addition, it was deemed important to apply the same process with the additional use of Process Capability, regarding the total time depending on the period of the day and the size of the order, as well as for the time per service department, so that the stages, where the service process does not meet the appropriate conditions, can be identified efficiently.

4. Company presentation and customer service

The company that was examined is a small enterprise that supplies and sells building materials and tools, located on the island of Crete, which entails certain problems and opportunities. Specifically, the restocking process takes a greater amount of time because of nautical transfers, requiring proper stock monitoring and organization to avoid shortages. Additionally, because the marketplace is small, the competition is known, so the need for customer retention is high.

The flow diagram in Figure 1 presents the service process in detail, while the time was recorded for each section. More specifically, when the customer arrives at the enterprise, they have two options: warehouse 1 (T1.1), the small warehouse and warehouse 2, the large warehouse. Subsequently, the customer is picked up by the corresponding salesperson

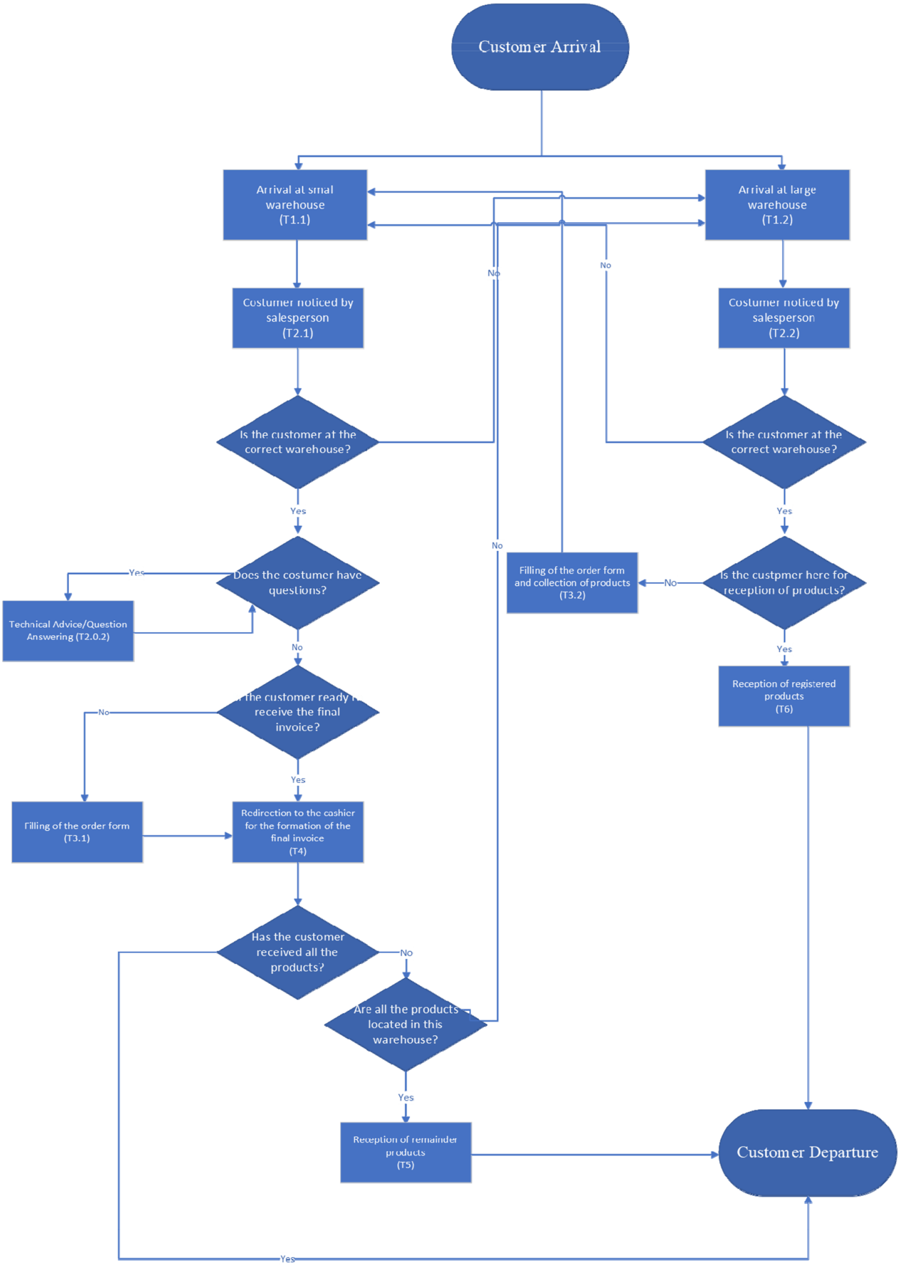

Figure 1. Flow diagram of the customer service process in the company. **Source:** Authors' own creation

depending on the warehouse they visited, (T2.1) and (T2.2) respectively, and either the items are collected or they are redirected to the other warehouse if the products they request are not there (T2.0.2) and then follows the collection of the products and the completion of the order form in the ERP, (T3.1) and (T3.2). In addition, the customers of warehouse 1 are capable of acquiring technical advice and questions regarding the materials or their application (T2.0.2). Then the customer proceeds to the register located in warehouse 1, to receive the sales document and pay (T4) then if the customer has not yet received all the products that are located in warehouse 1, they wait for the seller to bring them (T5). Finally, if the customer also needs to receive products from warehouse 2, after receiving the document from the cashier, they move to warehouse 2 (T6) and then the process is completed.

5. Six Sigma applications: a case study

The subject examined in this article is the customer's service time. Specifically, the service time is the sum of the times allocated to all departments that the customer needs to visit until their departure. Thus, the purpose of the analysis is to find the deviations in service time, based on order level and using the Six Sigma method to eliminate the causes of these deviations. The goal of the analysis is to optimize service times and align them with what the customer considers fair. Another reason that service time was chosen as a basic parameter is that delay usually leads to complaints. Another reason for choosing the parameter is that it has been reported as a common customer complaint. In particular, the construction sector is very demanding and delays can alter the completion date of a project significantly, so when the waiting time increases, there is an expression of dissatisfaction from the customer and a demand for immediate service.

5.1 Define phase

The Define phase aims to identify customer requirements, the clear definition of the problem and establish the project vision, in order to create the foundation for the successful implementation of DMAIC (Caballero-Morales and Bonilla-Enríquez, 2022; Solanki and Desai, 2021). So, an action plan was developed in order to define the project objectives, the timeline, the expected outcomes and the responsibilities of the team, by establishing effective communication and a shared understanding among participants. The project team consisted of the general manager (champion), the quality manager (team leader), the sales manager, the warehouse manager, two cashiers and two salespersons. The action plan is presented in Table 2.

Subsequently, a survey was conducted regarding the company's customer service problems to determine the most important. Thus, in Figure 2, the Pareto analysis for service problems is presented, where it is clearly evident that service time was the most important problem in customer service, since it has the highest percentage.

Furthermore, the team developed a supplier, input, process, output and customer (SIPOC) diagram to define the project scope and obtain an overall view of the customer service process (Table 3). The diagram identified the key suppliers, inputs, process steps, outputs and customer requirements, supporting the project objective of reducing the average service time by at least 15%. Consequently, service time was selected as the project's Critical to Quality (CTQ) characteristic.

Figure 3 presents the CTQ tree for service time. The analysis showcased that quick service, accurate product delivery and efficient customer communication as the key customer requirements. To achieve these goals, the company focused on reducing the waiting time, enhancing the knowledge of the staff on products and improving the form completion process.

5.2 Measure phase

The main purpose of this phase is to collect data from the current process, as well as convert the problem into a measurable form. Another important part is to validate the measurement method and assess the current situation, so that it can be the basis for improvement (Rajak *et al.*, 2024). Thus, the team formulated a CTQ data collection plan, which included the type of data collected, the sample formats, as well as the methods of measuring and capturing the data.

Table 2. Project charter

Project title: Improvement of the total service time	
Background and reasons for selecting the project	
The subject we are studying concerns customer service time, per service department and overall. The construction sector has very little margin for delay; therefore, the speed of service and the provision of correct products are key factors for customer satisfaction	
Aim of the project	
Reduction of the median service time by at least 15%	
Project champion	General Manager
Project leader	Quality Control Manager
Team members	Sales Manager
	Warehouse Manager
	Cashier I
	Cashier II
	Salesperson I
	Salesperson II
Characteristics of product/process output and its measure	
CTQ	*Measurable and specification*
Service time	Time in minutes
Expected benefits	Opportunity to improve customer satisfaction and company reputation. Potential financial benefits for the company and time savings for other tasks
Schedule	Define: two weeks, Measure: three weeks, Analyze: five weeks, Improve: three weeks, Control: two weeks

Source(s): Authors' own creation

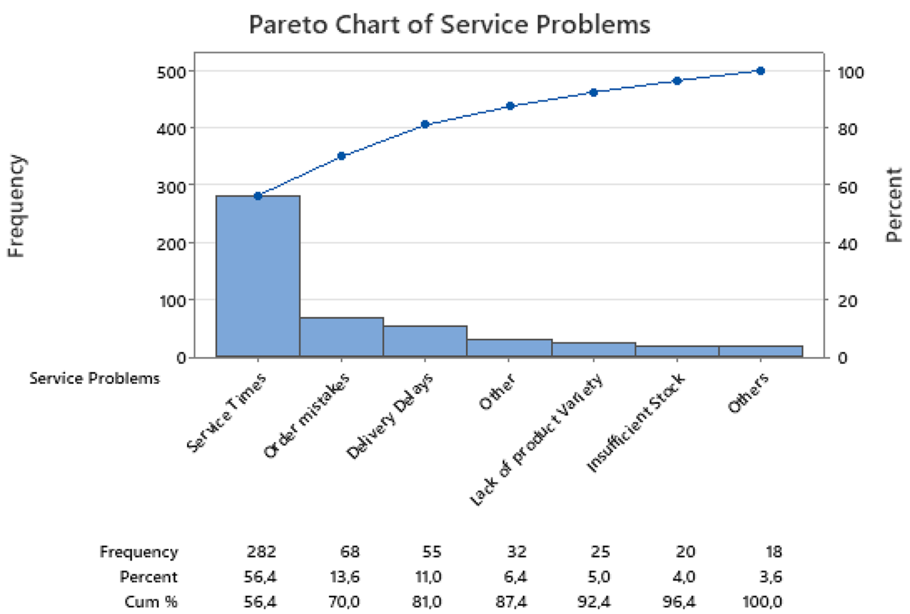

Figure 2. Pareto diagram for the service problems in the company. **Source:** Authors' own creation

Table 3. SIPOC diagram

Suppliers	Inputs	Process	Outputs	Customers
-Suppliers of timber	-Customer's questions for correct selection	-As it has been described in the previous Section	-Products reception	-Local construction companies
-Suppliers of tools and machines	-Description of the problem/work they need to do		-Technical advice	-Contractors
-Suppliers of chemical products	-Price range		-Delivery	-Craftsmen
-Suppliers of insulation materials				-Painters

Source(s): Authors' own creation

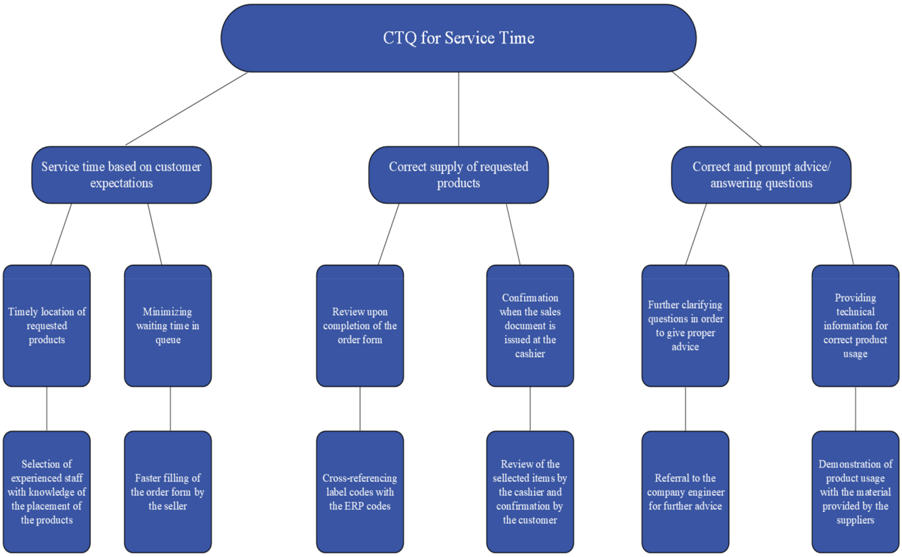

Figure 3. CTQ's for service time. **Source:** Authors' own creation

Subsequently, the basic parameters of the CTQ and the process, the assessment and accuracy of the data quality and the metric system were determined. A sample of 200 customer cases was then collected for the survey, recording the time in minutes for each department (T2,T3,T4,T6,T2.0.1,T2.0.2).

(1) T1: Customer arrival at warehouse 1 (small), 2 (large)

(2) Time T2: Customer pickup time by a salesperson (minutes)

(3) T2.0.1: Customer redirection to the appropriate department in case the item they want is not there. Values (Yes/No)/(Y/N)

- If the value is Yes, a value is given to Time T.2.0.1 in minutes

(4) Time T3: Time to complete an electronic order form (minutes)

(5) Time T4: Time allotted for paying and receiving the document (minutes)

(6) Time T5: Time to receive items from the customer, possible assistance with loading (minutes)

- If the value is 0, it means that the customer had received all the products before paying

(7) T6: Customer transfer from the small warehouse to the large one to receive materials that are in the document and were not available in the current warehouse (mixed orders). Values (Yes/No)/(Y/N)

- If the value is Yes, a value is given to Time T.6 in minutes

(8) T2.0.2 Possible search for technical advice before purchase. (Yes/No)/(Y/N)

- If the value is Yes, a value is given to Time T.2.0.2 in minutes

The data was then examined in relation to normality with the help of the Minitab statistical software, to estimate the basic efficiency of the procedure. The confidence level chosen was the default 95% and it was observed that the *p*-value of the test is very small $p < 0.005 < 0.05$, as shown in Figure 4, which means that the data came from a non-normal population. Also, the goodness-of-fit test was performed for the data among the possible distributions, but none managed to fit the data and the data were not transformed into a normal distribution even after the Box–Cox and Johnson transformation, since the *p*-value was too small, as shown in Figure 5 (Montgomery, 2019).

It is important to determine whether the collected data is predictable and stable in terms of the service process and this is done by using the individual-moving range (I-MR) diagram, shown in Figure 6. Thus, we observe that the service process went out of control at some points, indicated by the red squares, meaning that specific customers were delayed in being served more than the expected time. Therefore, the variation in service time should be reduced. These results were expected since each customer has different needs and it is very difficult to predict the service time that needs to be allocated. Moreover, as none of the distributions fit the

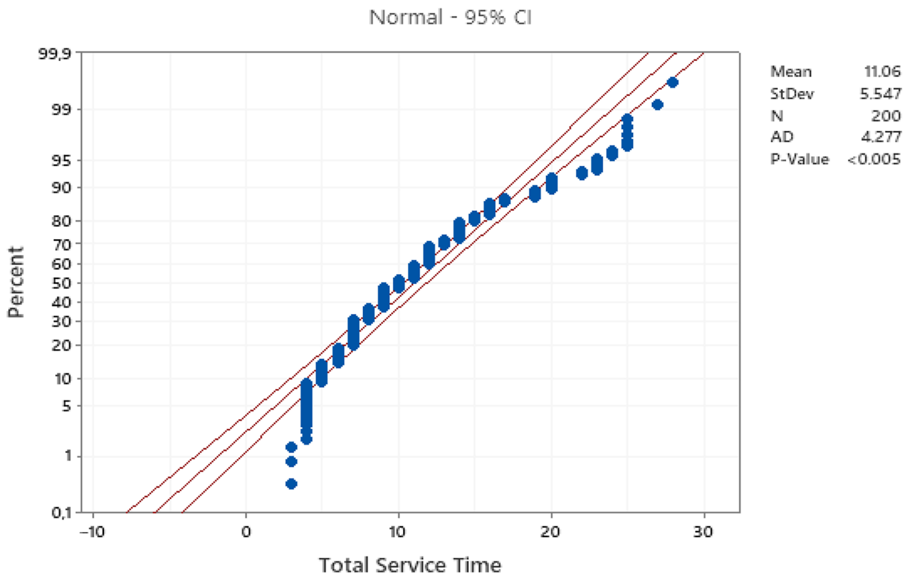

Figure 4. Probability plot of total service time before improvement. **Source:** Authors' own creation

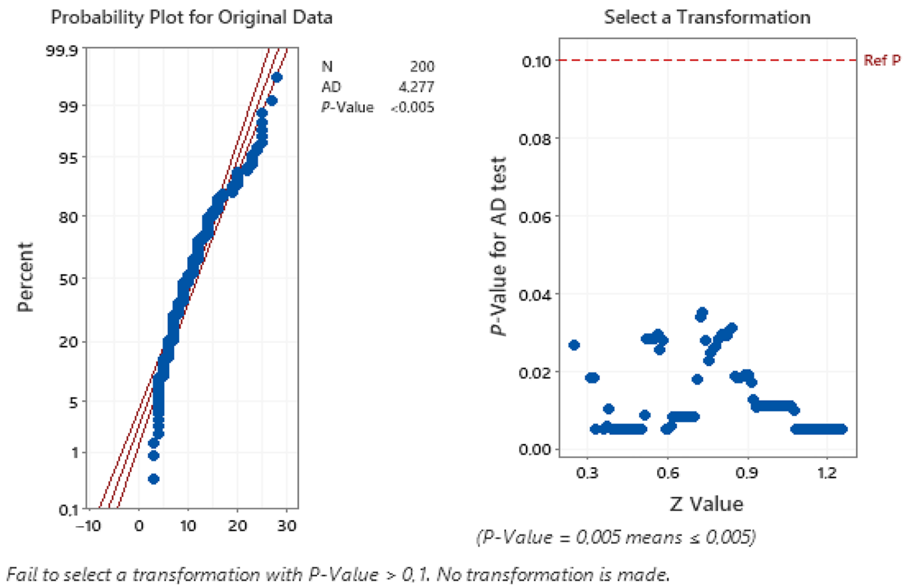

Figure 5. Johnson's transformation for the total service time before improvement. **Source:** Authors' own creation

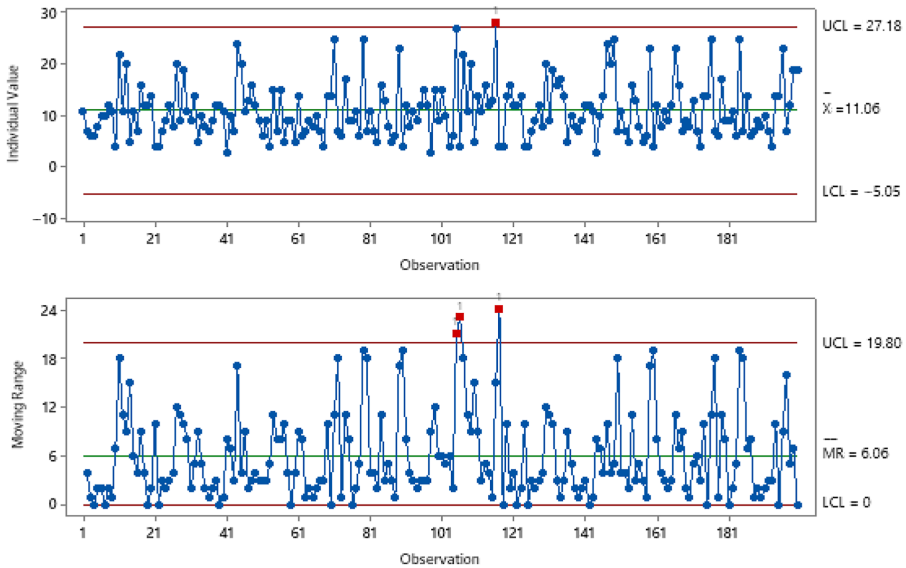

Figure 6. Control charts for the total service time before the improvement. **Source:** Authors' own creation

experimental data, the observed defects parts per million (PPM) total of 165,386.2 (142,342.7 of which refer to overtime, as shown in Figure 7) was considered as a baseline performance of the process. The capability indices *Cpk*, *Ppk* and *Cpm* were all less than the industry standard of 1.33. As a result, it was determined that the service time needs to be improved significantly.

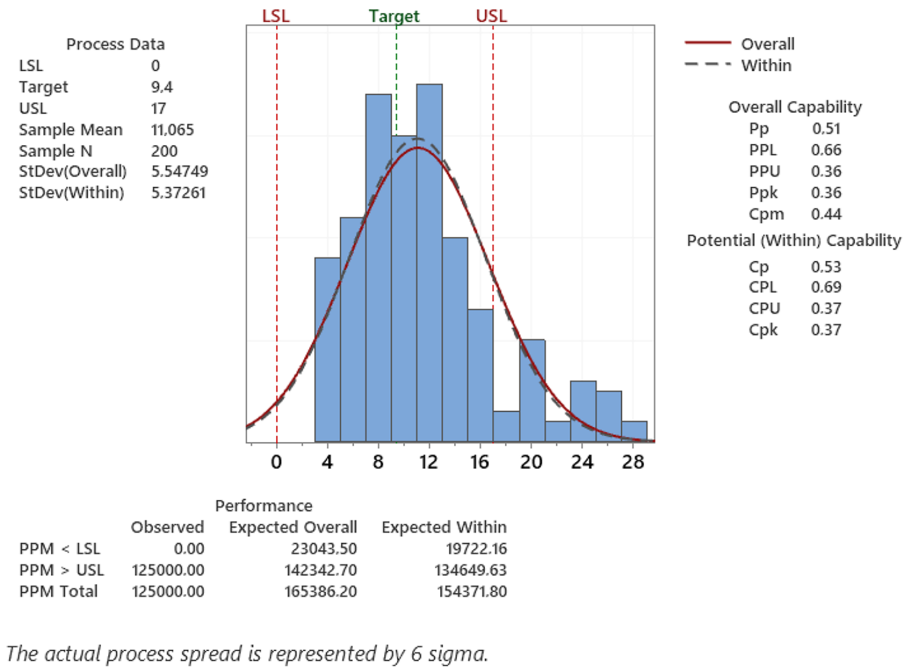

Figure 7. Process capability analysis of total service time before improvement. **Source:** Authors' own creation

5.3 Analyze phase

The Analyze phase aimed to identify and verify the root causes of variation in customer service time through the use of statistical analysis (Bhat *et al.*, 2021). Team members and employees directly involved in customer service participated in a brainstorming session, which resulted in the creation of the cause-and-effect diagram presented in Figure 8.

The proposed causes were then verified using statistical analysis when measurable data were available and GEMBA observations when direct measurement was not able to be made (Cherrafi *et al.*, 2019). Table 4 summarizes the validation method and conclusions for each critical cause.

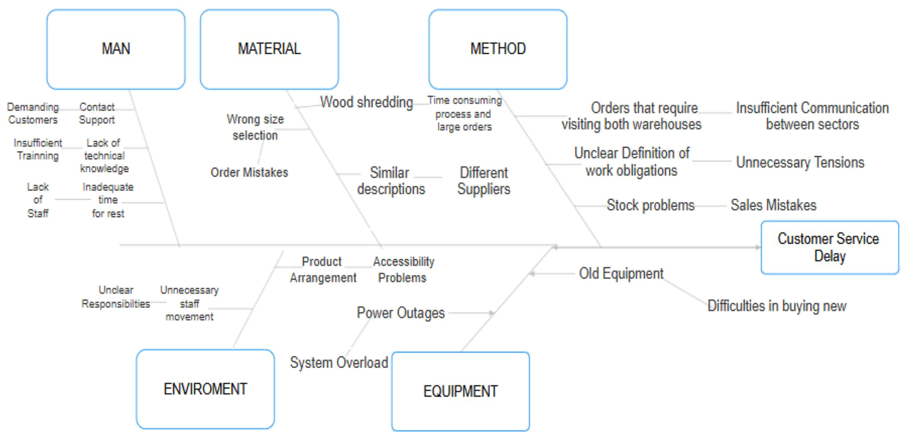

Figure 8. Cause and effect diagram for the customer service delay. **Source**: Authors' own creation

Table 4. Summary table of cause validation plan and result

No.	Category	Causes	Type of analysis	Observation	Conclusion
1	Man	Contact support	Measurable	Demanding customers	Root cause
2		Lack of technical knowledge	GEMBA	Insufficient training	Not a root cause
3		Inadequate time for rest	Measurable	Lack of staff	Not a root cause
4	Material	Similar descriptions	GEMBA	Different suppliers	Not a root cause
5		Wood shredding	Measurable	Time-consuming process and large orders	Not a root cause
6		Wrong size selection	GEMBA	Order mistakes	Not a root cause
7	Method	Orders that require visiting both warehouses	Measurable	Insufficient communication between sectors	Not a root cause
8		Unclear definition of work obligations	GEMBA	Unnecessary tensions	Root cause
9		Stocks problems	Measurable	Sales mistakes	Root cause
10	Environment	Product arrangement	GEMBA	Accessibility problems	Root cause
11		Unnecessary staff movement	GEMBA	Unclear responsibilities	Not a root cause
12	Equipment	Old equipment	GEMBA	Difficulties in buying new	Not a root cause
13		Power outages	GEMBA	System overload	Not a root cause

Source(s): Authors' own creation

The analysis revealed that significant delays were caused by the lack of technical knowledge among the staff, since employees often had to consult the company engineer or suppliers before responding to customer requests. Seasonal workload also affected service performance, particularly during the summer, when increased construction activity raised order preparation times and reduced staff efficiency.

Contact support was identified as another major source of delay. Customer calls concerning product availability or technical advice were frequently transferred to salespersons, interrupting in-store service and increasing waiting times for both physical and telephone customers. The similarity of product descriptions in the ERP system also created confusion when employees searched for item codes. Similar products supplied by different vendors increased the risk of incorrect sales, customer returns and additional service delays. Of course, eliminating alternative suppliers is not a solution, as product variety is a key element of the company and provides different options to the customer. Wood cutting created a further bottleneck because it required one employee for periods ranging from five minutes to one hour, temporarily reducing the available service capacity.

Errors in product dimensions also affected service time. Several products appeared visually similar and required additional measurement to confirm the correct size, increasing service duration but reducing the risk of incorrect orders. Furthermore, mixed orders were associated with significant delays because customers had to collect products from both warehouses. These delays were intensified by differences between ERP inventory records and actual stock levels, which required employees to confirm product availability manually. The inconsistencies were mainly linked to previous sales errors and delayed stock updates.

Outdated job descriptions also contributed to inefficiency. Unclear responsibilities created uncertainty and interpersonal tension, which resulted in the disruption of coordination and customer service delays. Additionally, warehouse layout and unnecessary employee movement were additional causes of delay. Difficult access to products increased retrieval time, while employees frequently interrupted assigned tasks to assist with other activities, creating confusion and affecting workflow continuity.

Finally, although equipment maintenance was performed regularly, no new equipment had been purchased during the previous eight years, increasing the risk of malfunction during loading operations. Frequent power outages also created the circumstance that employees had to complete orders manually without ERP access, thus increasing delays and the chance of errors.

5.4 Improve phase

The improve phase focused on implementing corrective actions to address the validated root causes and achieve the project objectives (Solanki and Desai, 2021). The implemented improvements are summarized in Table 5.

Beginning, a change was made regarding telephone service so that it would not hinder service. Telephone calls were redirected to salespersons only when they were available; otherwise, customer requests were recorded and returned later. Call center staff were also trained to handle routine enquiries, reducing interruptions during customer service. Following this, regarding work obligations, the current responsibilities of each employee were reviewed with by the personnel manager; the documents were renewed and were handed to the employees for review and possible questions. After the review period, each agreeing employ would sign the document and the general rules and obligations document of each department would be posted on a board. Thus, it became clear to each employee what is expected of them from the company and the amount of unnecessary tensions was reduced significantly.

Regarding the problem of product arrangement, because of the variety and variability of the products, it is possible for mistakes to be made in the customer's order. When the products are not arranged in a certain pattern so that the employee can get accustomed with them, it is certain that there will be delays in the service process in order to locate the product. Thus, the products were separated based on size and ease of loading and zones were created for each category, while barcode labels were placed for ease of identification.

Finally, regarding the stock problems, the major issues presented refer to sales mistakes and untimely registration of the invoices, which affect the ERP stock. Thus, after discussion with the employee responsible for the document registration, it was decided that the maximum duration between the arrival of the products and the registration of the invoices would be set to two days. Regarding the purchases, the ERP would be sufficiently updated and the salespersons would be trustworthy of the displayed stock. Additionally, a team consisting of a salesperson and the registration employee would check the stocks on the ERP system for possible mistakes every 15 days and inspect visually when a strange deviation is presented. So the detection of sales' mistakes became easier and their correction could be done in a timely manner.

Table 5. Validated causes and suggested solutions

Validated cause	Suggested solutions
Contact support	Notifying the customer of possible delays and saving their contact information in order to be called back when there is availability
Unclear definition of work obligations	(1) Review of the current work obligations (2) Catalog recording and signing for the obligations of each department and employee
Product arrangement	Separation of similar products and labeling with description and barcode
Stock problems	(1) Timely registration of invoices from the moment of receiving the products (2) Intensification of stock checks every 15 days

Source(s): Authors' own creation

After the implementation of the solutions, a new sample of 200 cases was collected to reveal the effects of the changes. Specifically, Figure 9 shows the diagram for checking normality, in which it is revealed that the population is not normal, due to the low value of $p < 0.0005 < 0.05$ with the same Confidence level of 95%; the mean value is 8.035 regarding the service time, showing a significant decrease (27.35%) compared to the initial 11.06, which is satisfactory since the initial goal was a 15% reduction. Then, the Johnson and Box–Cox transformation could not find a suitable transformation, as shown by the low *p*-value.

Moreover, as none of the distributions fit the experimental data, the observed defects PPM total of 7470.67 (2174.4 of which refer to overtime, as shown in Figure 10) was considered as a baseline performance of the process and while the capability indices *Cpk*, *Ppk* and *Cpm* are all less than the industry standard of 1.33, it is clear that there is a 95.48% reduction in the defects. This is important because of the nature and unpredictability of customer service it is very difficult for the process to be within standards; however, the results presented a clear indicator of a significant reduction in service time as well as a certain smoothness of the process.

Finally, Table 6 presents the results of the improvement, where the following can be pointed:

(1) The mean of the service time was reduced to 8.024 from 11.065 min (27.35%)

(2) The standard deviation was reduced to 3.144 from 5.547 (43.32%)

(3) The Coefficient of variation (CV) was decreased from 50.14 to 39.13 (21.96%)

(4) The PPM of total rejections was reduced to 7470.67 from 165,386.2 (95.48%), which makes clear that the improvements have yielded results

(5) The yield of the service process has been increased from 83.46 to 99.25 (15.8%)

As preliminary testing indicated a significant departure from normality ($p < 0.05$); in order to increase the validity of the results a nonparametric Mann–Whitney U test was utilized to evaluate the variation in total service time between the phase before the intervention and the phase after (see Figure 11). The analysis revealed a statistically significant decrease in service

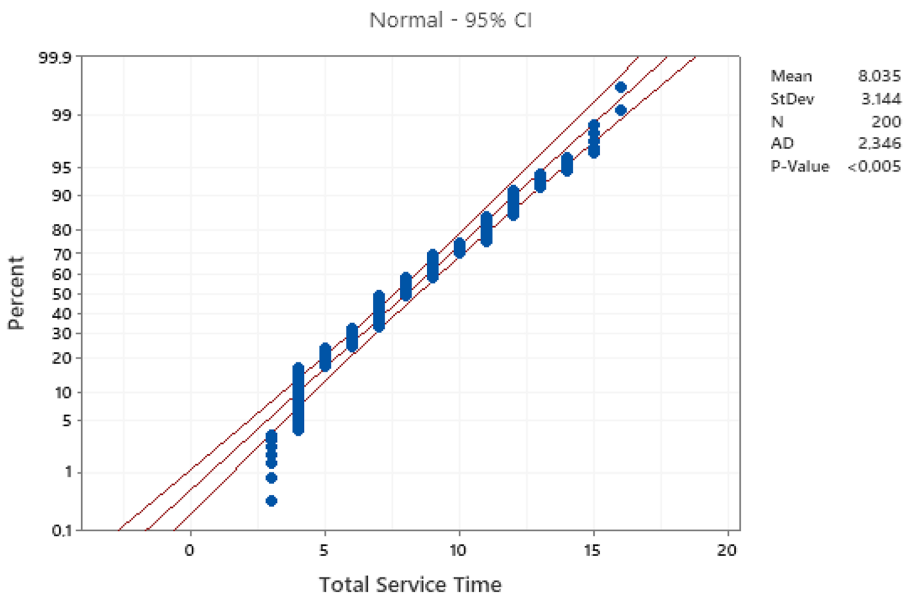

Figure 9. Probability plot of total Service time after improvement. **Source**: Authors' own creation

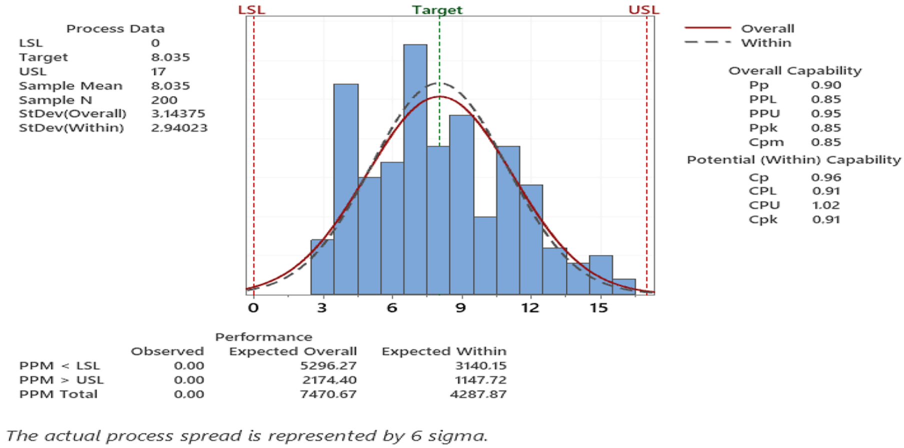

Figure 10. Process capability of total service time after the improvements. **Source**: Authors' own creation

Table 6. Summary of project improvement for the customer service process

Service time	Min	Max	Range	Mean	SD	CV	PPM	Yield
Before improvement	3	28	25	11.065	5.547	50.14	165386.2	83.46
After improvement	3	16	13	8.035	3.144	39.13	7470.67	99.25
Change Percent				−0.2735	−0.4332	−0.2196	−0.9548	0.158

Source(s): Authors' own creation

time ($W = 46{,}453$, $p < 0.001$), indicating that the observed difference is highly unlikely to be stochastic. Specifically, the median service time was reduced from 10 min to 8 min, which is a difference of 2 min and the 95% confidence interval (95.01% CI: [1, 3]) doesn't include zero in the range, showcasing that the improvement is likely to be reliable. This interval provides a precise estimation, suggesting that the real reduction in service time is included within the 1-to-3-min range. However, it is crucial to clearly distinguish between this statistical significance and its managerial significance. While the statistical test validates the mathematical presence of the change, the managerial significance of a 2-min median reduction per customer is profoundly impactful for the organization. In a high-demand small enterprise, such incremental time savings compound daily, unlocking substantial capacity for the workforce and preventing queue buildup. Regarding causality, while these findings strongly associate the corrective actions with the improved process efficiency, establishing absolute causality in a dynamic field setting requires cautious interpretation. External operational variables or shifts in customer behavior could partially influence service durations. Nevertheless, the magnitude of the improvement, coupled with the structured implementation of the DMAIC phases, supports an association between the LSS interventions and the observed enhancement in service quality and operational efficiency. The findings are consistent with previous LSS studies that reported performance gains through systematic reduction of process variability; however, the present study extends this evidence to a customer-facing SME operating in the construction materials sector.

These changes can also be perceived at a human and managerial level. Moreover, the 27.35% reduction in service time impacts the overall service quality and the perceived customer satisfaction significantly. Especially within a service-intensive environment, the

Method

η_1: median of Total Service Time Before
η_2: median of Total Service Time After
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
Total Service Time Before	200	10
Total Service Time After	200	8

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
2	(1; 3)	95,01%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	46453,00	0,000
Adjusted for ties	46453,00	0,000

Figure 11. Mann–Whitney test of the total service time for before and after comparison. **Source**: Authors' own creation

compressed service cycles correlate directly with an enhanced customer experience. Additionally, the 15.18% increase in process yield signifies optimized resource allocation and bolstered reliability, which improves service consistency and reduces operational expenditures. When combined, these improvements fortify the organization's competitive advantage by facilitating quicker service times without errors, thus providing sustainable performance and customer retention. The convergence of operational and customer-centric outcomes highlights the strategic utility of the DMAIC framework extending beyond statistical process control.

5.5 Control phase

The purpose of this phase is to confirm the results and determine the effectiveness of the improvements. More specifically, it is expected that the improvements of the research need to be maintained over time, while the basic condition for maintaining the improvements is the stabilization of the method, which is difficult due to the continuous changes that develop in the environment of a business (Sordan *et al.*, 2025).

For the monitoring of the improvements in the process, an I-MR control chart was constructed as shown in Figure 12. As it can be observed, the process is in control despite the existence of some elements outside the limits, as shown by the red indicators in the diagram.

Furthermore, based on the dot plot in Figure 13 it can be observed that the values of the service time after improvement are less dispersed compared to before improvement and also there is less deviation in the service times, with the maximum being 16 min after the improvement, while before it was 28 min. Therefore, it can be concluded that the corrective actions have already yielded positive results in the service time, but there is still room for improvement.

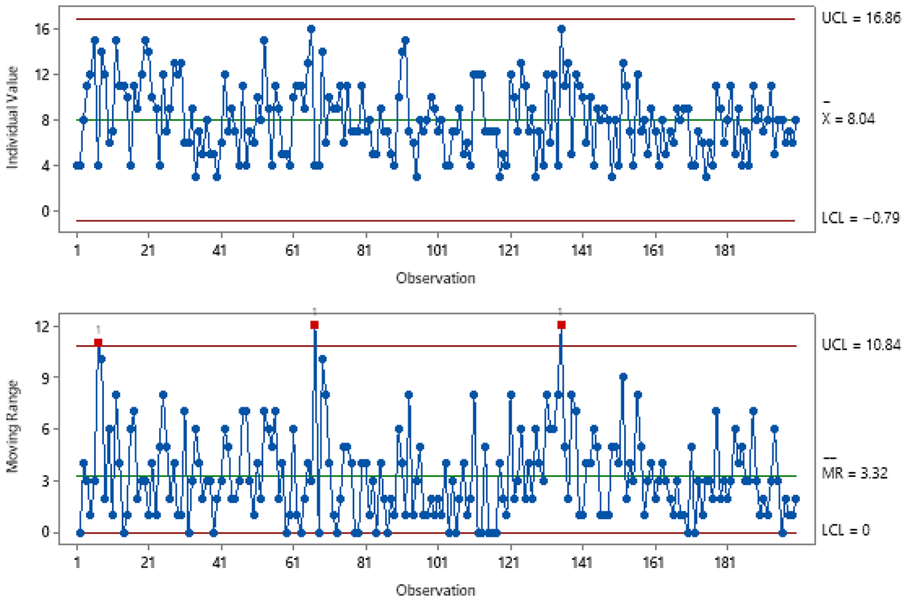

Figure 12. Control chart for total service time after the improvements. **Source**: Authors' own creation

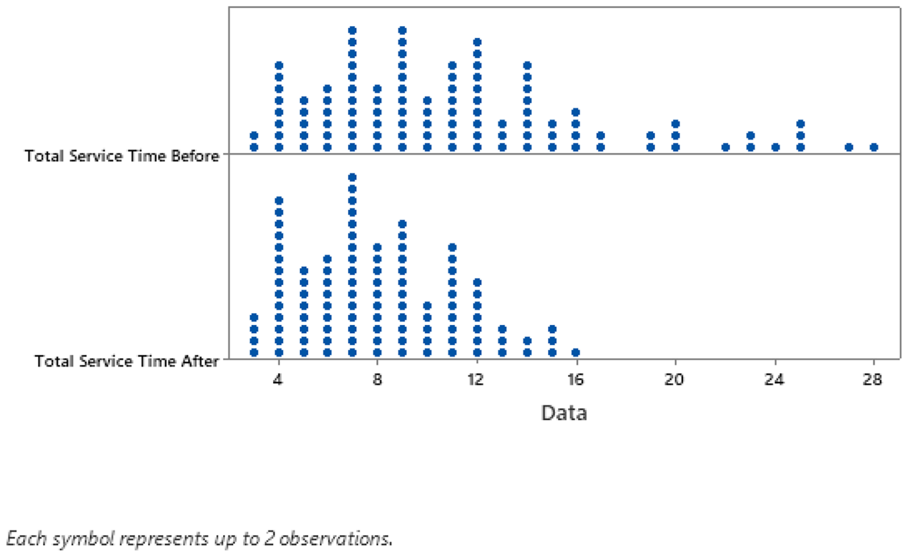

Figure 13. Dot plot of total service time before and after the improvement. **Source**: Authors' own creation

Moreover, the business decided to establish inventory control by forming control groups. Specifically, every 15 days, a group will be formed consisting of the invoice registration manager and 1 salesperson, which will check the items that were sold during that period based on the ERP system, but to avoid delays, various actions are required. Specifically, a special index had to be created in the ERP by the partner who provides ERP support. Then, a meeting was scheduled with the salespersons in order to understand the process and the method of checking and recording the products that present problems. It was also decided to swap the salesperson who would participate each time, so that everyone could learn the process and identify the points where mistakes could occur. In addition, to avoid problems with the salesperson's absence, this check takes place toward the end of the day, when the service flow is maintainable by the other employees. In addition, effective communication is very important in order to maintain these changes, since any change in the way a business operates can create unforeseen problems, which should be recorded and controlled. Additionally, it is very important to examine the efficiency of the improvement, its ease of implementation as well as the final overall benefit to the company.

Subsequently, it is considered beneficial to review the company's storage spaces. As the company has many bulky materials that occupy a large area and the available spaces are significantly affected by demand, some items are not easily accessible. Therefore, the company must constantly review the availability of its storage space and if the problem persists, consider setting up a special space for items that are in demand during the period, taking advantage of the available outdoor space.

Finally, it is worth noting the importance of contact support. More specifically, serving customers who are not present in the store is important, and if not handled properly, it creates problems both in serving physical customers and in acquiring new ones. Therefore, the company must consider alternative ways of managing them, such as redirecting calls to the company's engineer or structuring a service department for phone calls. A summary of the results and actions taken is presented in Table 7.

Table 7. Summary of results

Problem	Action	Result	Benefit
Contact support delays	Process optimization Protocols for client notification Notification for future communication	Reduction of waiting times within call queues Reduction of service times for current customers	Customer satisfaction is enhanced, as clients value clear and direct communication
Unclear definition of work obligations	Systematic evaluation of existing documentation Refinement of operational obligations to ensure clarity and precision Verification of the updated obligations through employee consultation	Operational processes are streamlined through the establishment of clear role definitions, ensuring that all employees possess a precise understanding of their individual responsibilities	Enhancing customer service outcomes through process optimization and the mitigation of unnecessary friction
Inadequate Product arrangement	Differentiation of similar products and labeling utilizing descriptions and barcodes	Optimization of product layout to enhance retrieval efficiency, alongside the establishment of designated loading zones to streamline service operations	Enhanced efficiency in product localization Expedited customer service delivery Streamlined inventory inspection processes
Incorrect stock data	Prompt registration of invoices in a timely manner upon product receipt Implementation of rigorous stock inspections at 15-day intervals	Expedited customer notification regarding product availability, as the requirement for supplementary verification is eliminated	Streamlined and optimized inventory replenishment procedures Expedited customer service

Source(s): Authors' own creation

6. Lessons learned and implications

The present study investigates the application of the Six Sigma DMAIC framework within a small enterprise by focusing on the optimization of customer service performance. The findings reveal a significant 27.35% reduction in average service time, a result that considerably surpasses the initial objective of 15%. This outcome outlines the premise that even relatively modest data-driven methods can cause measurable and substantial improvements within an SME environment. Although this improvement validates the effectiveness of the implemented corrective measures, its broader implications are further explained when contextualized within the existing LSS literature.

The results align with prior research suggesting that structured methodologies, such as DMAIC, can significantly enhance service quality and process efficiency, even within resource-constrained environments. Specifically, the critical role of leadership commitment to quality, as identified in this study, supports the findings of Psomas and Deliou (2024), who claim that strategic resource allocation and organizational support constitute fundamental success factors for process improvement. Furthermore, the importance of employee training and the challenges associated with resistance to change resonate with the findings of Psomas and Fotopoulos (2010), illustrating that SMEs frequently encounter substantial implementation difficulties stemming from limited familiarity with continuous improvement methods and entrenched routines.

Other than process optimization, this study also highlights the vital role of operational enablers, including warehouse spatial configuration and inventory precision. The mitigation of delays related to product retrieval and stock verification indicates that process performance is linked to assisting systems, such as physical organizational structures and ERP reliability, which aligns with Dong *et al.*, 2026 findings. This finding reinforces the broader consensus in Lean management literature that waste reduction is not confined to core service functions but encompasses all organizational processes, which Nawaz *et al.* (2026) also mention.

A further significant insight pertains to the important role of organizational culture and cross-functional teamwork. The establishment of a dedicated Six Sigma team fostered internal collaboration and enhanced communication, thereby streamlining the execution of process modifications. This finding substantiates existing research identifying cross-functional teamwork as a cornerstone of successful quality improvement, such as the findings of Gumara Rigol (2026), especially within smaller organizations characterized by overlapping responsibilities and not well-established professional roles.

The findings of the present case study yield significant theoretical, managerial, practical and social implications, creating an integrated framework for understanding LSS applications within small and medium enterprises. Theoretically, this article enriches the existing literature by contextualizing LSS implementations within resource-constrained environments, addressing the academic gap highlighted by Skalli *et al.* (2025) and Elmarzouki and Jiuhe (2026). While previous studies, such as those by Shamsuzzaman *et al.* (2018), primarily concentrate on large-scale settings with abundant resources, this research adapts the Six Sigma methodology within an SME environment. By utilizing a complete method of statistical validation, like the Mann–Whitney U test, for the evaluation of service time, this study expands simple observation metrics in order to provide robust evidence for the improvement of the process. Additionally, the present study contributes to the existing DMAIC literature by providing context-specific evidence of how the methodology can be applied alongside organizational capabilities such as strategic leadership, employee engagement and organizational culture. Furthermore, the analysis confirms the findings of Dong *et al.* (2026) by underlining the critical importance of operational components, including spatial organization and inventory management, for the optimization of service time. By doing so, the study contributes to the academic discourse by offering context-specific empirical support for prior assertions regarding the multi-sector transferability of LSS methodologies and indicating their potential viability in diverse service environments.

On a managerial and practical level, the implications of this study provide a reproducible and systematic methodology for service time optimization. The statistical confirmation of a median service time reduction of two minutes, validated by a robust confidence interval, translates directly into daily operational capacity. In a high-demand small enterprise, this specific incremental time saving compounds rapidly, unlocking substantial capacity for the workforce and preventing critical queue buildups during peak hours. The integration of the DMAIC methodology illustrates that organizations with constrained resources can achieve these significant operational enhancements, confirming the arguments of Psomas and Deliou (2024) regarding strategic resource allocation. The findings challenge the notion that major capital expenditure is required for process improvement, showing instead that incremental adjustments, such as layout optimization and stock reliability, impact service time significantly. Specifically, the study emphasizes that the continuous commitment of leadership is foundational for the sustainment of the improvements, since in its absence it is possible for organizations to regress to a previous state. Furthermore, the findings showcase the clear need for continuous improvement of the workforce, which aligns with the systemic barriers as identified by Gaikwad *et al.* (2020). This study also highlights that leadership should actively involve employees in the redesign process in order to cultivate a feedback culture and reduce resistance to changes. Thus, practitioners are encouraged to utilize an inclusive approach that simultaneously combines process engineering, targeted employee training and performance monitoring. From a practical perspective, these findings provide SMEs with a context-specific example of how DMAIC can be implemented without relying primarily on major capital investments, through targeted adjustments to process organization, inventory reliability, employee responsibilities and service coordination. These implications should nevertheless be transferred to other organizational settings with caution, as their applicability depends on the operational characteristics and resource constraints of each organization.

Finally, the findings suggest several potential social implications regarding operational efficiency, customer satisfaction and workplace wellness, which should be interpreted as possible extensions of the present findings rather than demonstrated outcomes. Since employee well-being and organizational climate were not directly measured, the reduction in service time and the enhanced transparency of procedures could potentially contribute to a better-structured work environment by reducing uncertainty and stress. Accordingly, effective process optimization might serve as an enabling factor toward a positive organizational climate. Furthermore, while reliable service and efficient operations may contribute to increased customer satisfaction, the establishment of a climate of trust that supports long-term customer relationships remains a potential implication that requires further empirical investigation. On a broader scale, the study offers potential insights for regional benchmarking. In smaller, highly competitive regional markets, improvements in service quality could potentially influence local operational standards. As a possible consequence, such competitive dynamics might encourage rival firms to evaluate their own services, thereby potentially contributing to aggregate service quality across the region. These broader impacts, however, were not examined further in the present study and should therefore be investigated in future research.

7. Conclusion

In this article, an implementation of the LSS DMAIC methodology took place within a small-scale enterprise that sells building materials, aiming to enhance the quality of customer service. Utilizing a data-centric methodology, the research elucidated the primary determinants of time delays and deployed targeted interventions for their mitigation. The observed reduction in total service time, combined with enhanced process stability and error reduction, validates the strength of Six Sigma as a functional method for optimizing operations in a resource-constrained service environment.

Transcending the operational gains, this study highlights the importance of attenuating process variability, particularly within the construction sector, where temporal delays and inefficiencies often affect organizational performance negatively. The findings suggest that even marginal improvements in service time lead to important organizational advantages, encompassing expanded service output and quantifiable benefits, exemplified by an estimated annual revenue increase of approximately US$ 80,000.

Furthermore, the present study provides a comprehensive resolution to the three research questions that were originally formulated. Initially, the findings demonstrate that the LSS DMAIC methodology is highly adaptable to the SME environment, provided the implementation follows a data-centric, rigorous methodology customized to the organization's specific operational needs (*RQ1*). Furthermore, the analysis highlights the critical implementation barriers, most notably the resistance to change and inherent organizational constraints, while simultaneously referencing vital success factors such as systematic employee training, leadership commitment and robust cross-functional synergy *(RQ2)*. Finally, the application of the DMAIC method resulted in quantifiable performance enhancements, most significantly a 27.35% reduction in total service time, complemented by a substantial reduction in errors and an overall optimization of process efficiency (*RQ3*).

Moreover, this research addresses a significant gap in the current literature, which has historically prioritized the study of medium and large-scale enterprises. Through the usage of data derived from an SME context, this study underlines the functional adaptability and scalability of LSS methodologies. The results indicate that, despite the resource constraints, SMEs are capable of attaining significant performance goals and executing structured improvement initiatives without necessitating substantial costs.

Beyond the showcasing of operational improvements, this study provides a new look into the mechanics through which LSS assists SMEs. The findings highlight that the successful integration of DMAIC is mostly dependent on the accuracy of organization capabilities and less on technological improvements. This helps to expand the current LSS literature by emphasizing that the key to successful implementation in customer-centric SMEs is the organization of the processes.

Concurrently, the study emphasizes that the long-term contribution of such initiatives resides in the incorporation of a continuous improvement philosophy and not solely in the short-term results. The embedding of quality-centric philosophy into daily procedures, combined with leadership commitment and active employee engagement, establishes a strong foundation for continual organizational growth.

Nevertheless, certain constraints need to be acknowledged. Since the study is based on a single case within a specific geographical region, the generalizability of the findings may be limited. Additionally, constraints regarding resource allocation, temporal factors and technical expertise, which are characteristic of SMEs, may have affected the range of the implementation.

In conclusion, the findings of this study indicate that the implementation of LSS has the potential to be both viable and effective within an SME where resources are constrained. When appropriately adapted to the specific organizational setting, the DMAIC methodology can support service efficiency, process improvement and the continuous improvement philosophy.

7.1 Limitations and future work

The main limitation of the study was that it was carried out during a period of reduced working hours for a short period of time. Specifically, the application of the method was carried out in the winter months, where weather conditions reduce the number of projects in the construction sector. In addition, another limitation during the study was the data collection for the service time, as the company did not have a specific recording and collection method and had to be formed, which delayed the analysis of the study. Additionally, the region where the research took place must be accounted for, because it is a small region of Greece and being an island creates some unique opportunities and limitations. Moreover, because the region is an island and product availability is limited and delayed, the warehouse managers need to plan carefully and retain their stocks accordingly, as a shortage of products could cause big dissatisfaction. Additionally, in a small region there are fewer available competitors, which results in each company having knowledge of the activities of the other. Therefore, the application of the methods used in this research in a bigger region should be done with caution and proper benchmarking, to avoid hasty and wrong results.

The company that was examined provides additional types of service that were not examined in this study, such as itinerary orders and iron processing. Thus, as a future study, customer satisfaction could be investigated both for the itinerary orders and the quality of the processed iron. In addition, another study could be the expansion of the data collection of the current study over an entire year. This will help to provide a complete picture of the company regarding customer service; it will lead to a better understanding of its problems and to their more immediate treatment.

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