Customer Service Optimisation and Management: A Case Study in a Telecommunications Company Using Queueing Model Simulation

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ABSTRACT

This study proposes a comprehensive improvement and control plan for customer service operations, leveraging queueing theory and process analysis to identify and address system inefficiencies. Through statistical analysis, the current operational state is assessed, followed by the simulation of service processes to model the system’s behaviour. The simulation enables the evaluation of various improvement strategies aimed at enhancing service efficiency and boosting productivity. Among the strategies explored, key actions focus on stabilising customer service processes to optimise performance and satisfaction.

OPSOMMING

Hierdie studie stel 'n omvattende verbeterings- en beheerplan vir kliëntediensbedrywighede voor, deur gebruik te maak van toustaanteorie en prosesanalise om stelselondoeltreffendhede te identifiseer en aan te spreek. Deur statistiese analise word die huidige operasionele toestand beoordeel, gevolg deur die simulasie van diensprosesse om die stelsel se gedrag te modelleer. Die simulasie maak die evaluering van verskeie verbeteringsstrategieë moontlik wat daarop gemik is om diensdoeltreffendheid te verbeter en produktiwiteit te verhoog. Onder die strategieë wat ondersoek word, fokus sleutelaksies op die stabilisering van kliëntediensprosesse om prestasie en tevredenheid te optimaliseer.

1. INTRODUCTION

The economic development of a nation is largely driven by its business sector, particularly service-oriented enterprises, which, according to recent studies, contribute about 70% of national gross domestic product [1]. This dominant share has positioned the service sector as the fastest-growing segment of the global economy over the past decade [2]. In light of its strategic importance, it is crucial to assess the capacity of these organisations to consistently meet and exceed customer expectations.

In today's competitive environment, service quality plays a pivotal role in shaping customer satisfaction, fostering loyalty, and driving repeat patronage and positive word-of-mouth [3]. To respond to these demands, numerous quality management frameworks have been introduced in the service sector over the past decade [4]. Among them, continuous improvement has emerged as the most widely adopted approach, owing to its effectiveness in enhancing competitiveness and operational resilience [5]. Modern organisations face increasing pressure to optimise their performance, and only those capable of reducing inefficiencies and institutionalising adaptive learning can maintain long-term viability.

Six Sigma has proven to be one of the most robust methodologies for achieving such outcomes. As a project-oriented management strategy, Six Sigma enhances processes, products, and services through a data-driven, customer-focused approach. Its implementation aims to elevate customer satisfaction, improve productivity, and generate favourable financial outcomes [6],[7]. By identifying root causes and eliminating defects early in the process lifecycle, Six Sigma promotes systematic and measurable improvements [8]. In customer service systems, this methodology supports the structuring of personnel and processes to minimise delays and to ensure that client needs are efficiently resolved [9].

A relevant case is that of the National Telecommunications Corporation EP (CNT EP), a public entity that delivers customer care through dedicated service centres. One of its centres has reported significant operational inefficiencies, with service levels below 40% and customer waiting times ranging from five to 56 minutes. These performance gaps necessitate a comprehensive analysis to identify the root causes and to implement corrective strategies [10]. Integrating queueing theory with Six Sigma methodology provides a strategic framework to move from reactive troubleshooting to proactive service system design [11]. Queueing models make it easier to examine customer flow, resource allocation, and operational bottlenecks, while Six Sigma reinforces data-based decision-making and fosters continuous improvement [12]. The synergy between these tools enables organisations to reduce process variability, enhance service delivery, and improve the overall customer experience.

The objective of this study is to design an improvement and control plan for the customer service system of CNT EP by applying queueing theory and operations scheduling. The proposed approach seeks to reduce waiting times, improve service levels, and increase productivity. To this end, the following steps are undertaken: analyse the current state of the customer service queue with respect to waiting times and performance indicators; develop a simulation model that accurately represents the system; evaluate multiple improvement scenarios using simulation; and propose a practical, data-supported plan to optimise performance and customer satisfaction.

2. THEORETICAL FRAMEWORK

Before referring to customer service systems, understanding what it means to serve the customer is necessary. Customer service is a set of procedures that are coordinated by the company, in which the customer–company relationship is managed by promoting customer satisfaction [13]. Therefore, customer service is always focused on seeking to meet the needs that customers have, and for this the company has physical, human, and infrastructure resources. This leads to the development of customer service systems. Thus, a customer service system is understood as a set of physical facilities and human resources in order to meet customers' needs quickly and thereby generate satisfaction and loyalty to the company [14], [15].

2.1. Waiting line analysis

In daily life, waiting lines are a constant presence, whether it is vehicles waiting at a red light or customers forming lines at financial institutions to carry out transactions. However, the fact that they are common does not mean that they stop causing problems for the organisations that manage them. Long waiting lines can lead to losses in time and money, and, in critical settings such as hospitals, they can even pose risks to human life [16].

The waiting line analysis consists of the study of:

- The disposition and distribution of arrival of customers
- Providing resources to offer the service

2.1.1. Disposition and distribution of arrival of customers

In the study of customer arrivals, it is essential to specify the source of customers, whether from a finite population (for example, in doctors' offices, where the number of patients is limited and no additional demand can be served) or from an infinite population (for example, in financial institutions where customers arrive continually). This distinction determines the appropriate probability distribution to use for modelling arrivals and estimating customer demand.

"Arrival distribution" refers to the speed or rate at which customers enter the system to receive service. However, to analyse customer arrivals properly, it is important to distinguish between the arrival time of each customer and the interarrival time – that is, the time between two consecutive arrivals (see Figure 1).

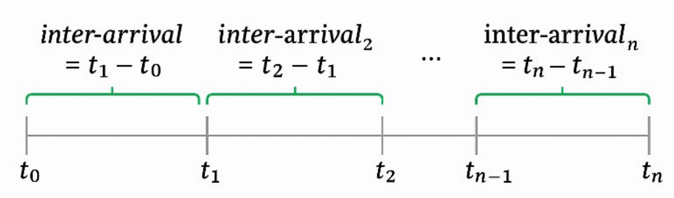

Figure 1. Time of arrival and time between arrivals.

The time of arrival corresponds with the moment of arrival, while the inter-arrival times correspond with the width of the interval: $(t_0, t_1, \ldots, t_n(t_1 - t_0)$.

To estimate customer demand, it is necessary to apply the **Poisson process**, which models the number of events (customer arrivals) that occur within a given time interval [17]. For the application of this probabilistic model, it is necessary to meet the following conditions:

- The customers arrive independently from one another.
- The arrival of customers has to be one at a time, and the probability of two or more arriving at the same time is zero.
- The number of customers arriving in one time interval is independent of the number of customers arriving in another time interval.

With these conditions fulfilled, the time between customer arrivals follows an exponential distribution (with parameter λ):

$$P(t) = \lambda \cdot e^{-\lambda \cdot t}$$

and the arrival rate of customers follows a Poisson distribution (with parameter λ):

$$P(n) = \frac{\lambda^n \cdot e^{-\lambda}}{n!}$$

2.1.2. Providing resources to offer the service

In the analysis of the waiting line, the speed of customer service must be taken into account; this can be constant or variable. Waiting lines are configured so that they can include multiple service staff, in a phased and channel flow design.

The most commonly used configuration is multiple channels with multiple phases. This arrangement includes consecutive service staff and multiple wait lines (Figure 2).

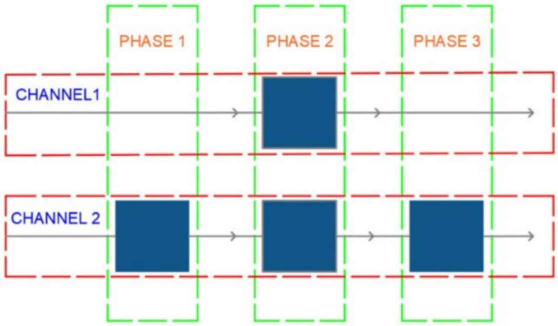

Figure 2: Configuration multiple channels and multiple phases

To solve these types of problems, analytical equations are developed for specific configurations. However, in more complex systems, where different processes are involved with varying times, customer demands, and a variable number of service staff, queueing simulation is used instead.

2.2. Waiting-line simulation

Waiting-line simulation combines probabilistic models (e.g., exponential distribution) and statistical functions (e.g., minimum, maximum, median) to represent the randomness and characteristics of the system. By analysing random variables, this tool monitors the occurrence of key events and the resulting flow generated by the system's internal interactions [18].

Given the complexity of these models because of the interactions they imply, the present work uses the JAAMSIM® software, which is programmed to carry out this type of study and offers certain advantages over other types of software [18].

2.3. Statistical process control

The statistical control of processes is a tool to manage quality in a company. Through control graphics, the limits are represented (either specification or control), which serve as a guide to control the evolution of the performance of a system.

The control limits correspond with the following: $\underline{X} - R$

For $\underline{X}$:

$$LC_{\underline{X}} = \underline{\underline{X}} \pm A_2 \cdot \underline{R}$$

where:

$\underline{\underline{X}}$: is the average of the averages of the samples taken

A_2: replacement factor

$\underline{R}$: is the average of the ranges of the samples taken

For $\underline{R}$:

$$LCS_R = D_4 \cdot \underline{R}$$

$$LCI_R = D_3 \cdot \underline{R}$$

D_4: factor for the upper control limit

D_3: factor for the lower control limit

To finish with the diagnosis, monitoring, and control of the operation of the system, it is essential to use the process capacity indices, which allow the user to decide on the ability of a process to meet a specific quality level and to identify possible improvements:

$$C_p = \frac{LES - LEI}{6 \cdot \sigma}$$

$$C_{p_i} = \frac{\mu - LEI}{3 \cdot \sigma}$$

$$C_{p_s} = \frac{LES - \mu}{3 \cdot \sigma}$$

$$C_{p_k} = [C_{p_i}, C_{p_s}]$$

$$K = \frac{\mu - N}{\frac{LES - LEI}{2}} \times 100$$

$$C_{p_m} = \frac{LES - LEI}{6 \cdot \sqrt{\sigma^2 + (\mu - N)^2}}$$

$$N = \frac{LES - LEI}{2}$$

where:

C_p: potential capacity index

C_{p_i} : lower capacity index

C_{p_s} : Superior capacity index

K: Process centering index

C_{p_m}: Taguchi index

LES: upper specification limit

LEI: lower specification limit

μ: average or average

σ: standard deviation

2.4. Improvement plan

The quality of a service is not a short-term goal, nor is it about creating a plan and failing to implement it. Quality is built day by day, through a comprehensive commitment that involves everyone, from management to advisers and all those responsible for delivering a service that satisfies the client.

Several methodologies can be chosen to realise an improvement plan; among them is the methodology of define, measure, analyse, improve, and control (DMAIC), known as a clear and easy-to-implement roadmap to improve the processes extracted from the Six Sigma tools (Figure 3).

This methodology establishes a path forwards, and applying the stages of the cycle would allow the benefits to be realised, as long as the problem or root cause is correctly defined [19].

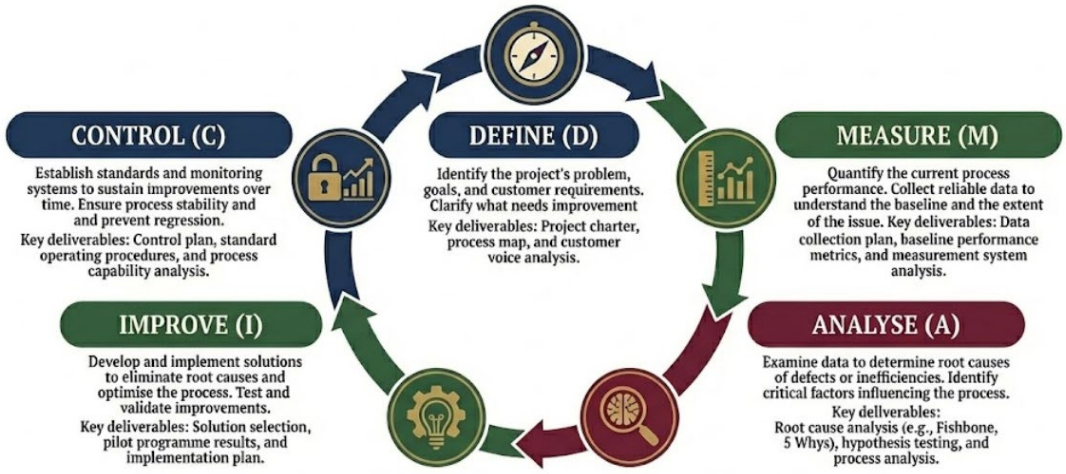

Figure 3: Six Sigma continuous improvement cycle (DMAIC)

3. RESULTS AND DISCUSSION

3.1. Description of the waiting line

The analysis was applied to the behaviour of the customer service system offered in one of the service centres of a telecommunications company. The problems presented corresponded to a failure to fulfil its value proposition when delivering a service, a low level of service, and a long waiting time (Figure 4).

This centre operates from Monday to Friday, opening at 8:00 and closing at 18:30. The centre works around 10.50 hours for five days a week; there is no service on weekends, and the hours of operation are not interrupted at noon.

Figure 4: Customer service centre layout

The centre consists of:

- Seventeen customer service stations (marked in yellow), where customers come to have their requirements met.
- Forty seats (marked in green), where customers are kept while they await their turn to go to the designated service module.
- A reception station (marked in purple) and shift generation, depending on the type of requirement that will be addressed.

The process applied is the following:

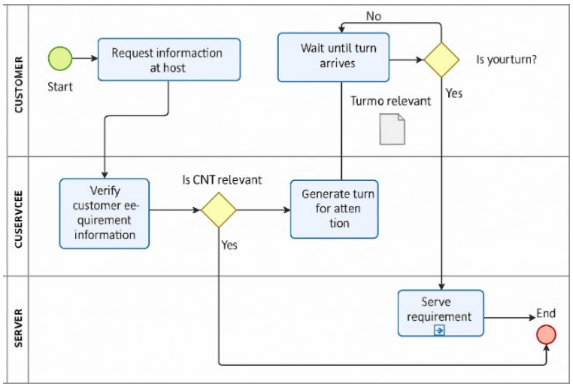

Figure 5: Customer service process

3.2. Waiting line analysis

For the present analysis, the records from the years 2022, 2023, and 2024 were considered, because it could be assumed that the behaviour of customers in search of the service has been maintained in recent years. A total of 395 962 cases were analysed.

3.2.1. Study of customers' arrival

For the analysis, it was necessary to identify the unusual data – those that were not the result of a normal behaviour corresponding to the arrival of customers at the service system. These data were excluded since they generated erroneous estimates and were not useful in simulating the system.

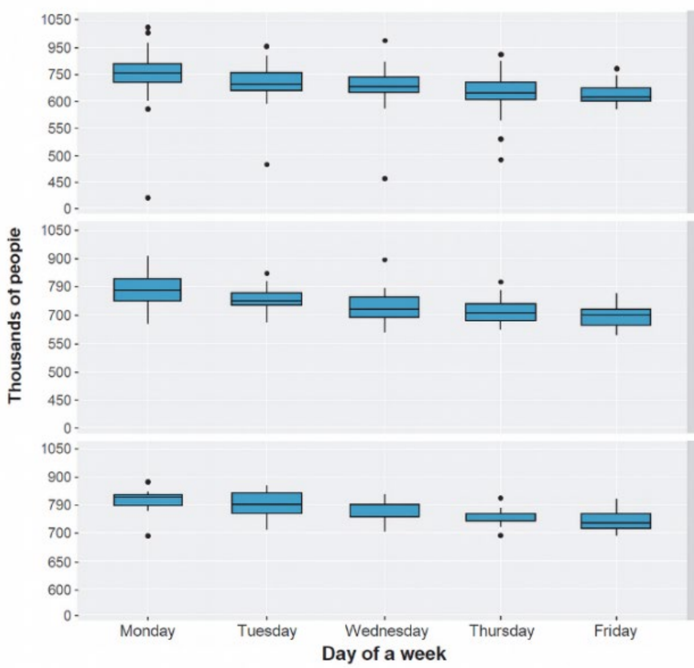

Figure 6: Box and whisker diagrams for the analysis period by years

It is common for this atypical data to occur; this system works in real life circumstances, and is subject to uncontrollable variables. In Figure 5, the black dots correspond to the atypical data, which were not taken into account in the analysis of the descriptive statistics (Table 1).

Table 1: Descriptive statistics of daily care

Day	Min	Max	Stocking	Standard deviation
Monday	570	924	737	70
Tuesday	526	836	674	69
Wednesday	475	817	645	69
Thursday	456	783	617	63
Friday	456	762	601	66

The demand for the care service is differentiated per day. In addition, on Mondays an average of 737 attentions are experienced, while on Fridays the average number of people attending is 601. To standardise the arrival rate between days, it was calculated as follows:

$$Arival\ rate = \frac{time\ operation}{demand}$$

The database that was obtained came from the following data collection. The system opened its doors at 8h 00min 00s and the last client arrived at 18h 2min 37s. The operating time on that day was equal to 10 h, 2 min and 37 s, or 602.62 min. Considering that on the same day 684 people were attended to, the arrival rate was calculated as 0.88 minutes per person.

Table 2: Arrival rates

Day	Stocking	Standard deviation
Monday	0,857	0,100
Tuesday	0,946	0,192
Wednesday	1,001	0,335
Thursday	1,005	0,109
Friday	1,048	0,116

Subsequently, the distribution function of customer arrival was identified, which was applied to represent this phenomenon (Table 2).

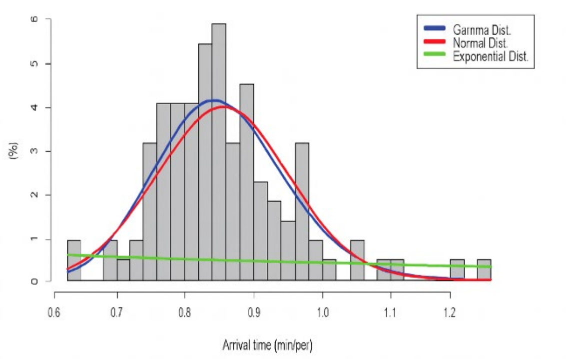

Figure 6: Distribution of arrival time – Monday

Figure 6 shows that the distributions that most closely approximate the actual data generated by customer arrivals are the gamma and normal distributions, while the exponential distribution is completely misaligned. To avoid subjectivity in selecting the distribution, a goodness-of-fit test was applied [20]. The results obtained from the Kolmogorov-Smirnov tests are presented in Table 3.

Table 3: Goodness-of-fit test - Monday

Distribution	E(x)	Var(x)	p-value	Conclusion
Exponential	0,857	0,100	0,000	Rejected
Gamma	1,005	0,109	0,486	Accepted
Normal	1,048	0,116	0,386	Accepted

The gamma and normal distributions could be used to represent the arrival rate on Mondays (it was accepted that they came from these distributions). In this case, it was preferable to use the gamma distribution. The same procedure was applied for the rest of the days. The arrival rates served by the care centre follow a gamma distribution with the parameters shown in Table 4.

Table 4: Goodness-of-fit test - Monday

Day	E(x)	Var(x)
Monday	0,857	0,010
Tuesday	0,930	0,009
Wednesday	0,972	0,012
Thursday	1,004	0,011
Friday	1,047	0,013

3.2.2. Study of customer service

In the context of customer service at the company, five key processes structured the majority of the interactions with users. These were: (A) **service subscription and plan modifications**, when clients requested the activation or adjustment of internet, mobile, or television services; (E) **billing and payment management**, which covered invoice inquiries, claims, and direct payment processing; (F) **technical support**, focused on resolving service disruptions, equipment replacements, or connectivity verification; (L) **post-sale service and device activation**, including the configuration and delivery of modems, SIM cards, or decoders; and (V) **appointment scheduling and verification,** used to coordinate service provision for specialised procedures. These processes define the operational core of in-person service delivery, and reflect CNT's role as a public telecommunications provider that is committed to service quality and user satisfaction. To study the distribution of customer service times, there was a need to identify the processes that are carried out. The 395 962 clients were served under the following scheme (Figure 7).

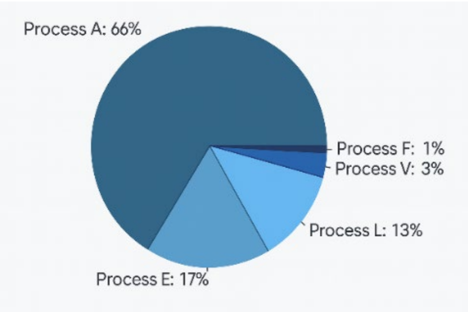

Figure 7: Proportion of care by process

To proceed, it was necessary to determine the time (in minutes) that service staff took to complete each of the previously analysed services. For this purpose, the same procedure used in the customer demand analysis was applied. A three-year analysis period was considered, and outliers in service times were identified and subsequently excluded to avoid biasing the time study. Statistical tests were then conducted to determine the probability distribution that best fitted the customer service time behaviour, shown in Table 5.

Table 5: Descriptive statistics by care process

Process	Min	Max	Mean	Standard deviation
A	0,02	26,85	7,46	6,35
E	0,02	26,77	7,90	6,21
F	0,03	12,18	3,60	2,73
L	0,02	32,97	9,18	7,76
V	0,02	32,37	8,33	7,77

Table 5 presents a descriptive analysis of the number of customers served per day by process type, aiming to explore the statistical behaviour of operational demand. Initially, this analysis sought to determine whether the data could be modelled using known theoretical distributions. However, after applying goodness-of-fit tests, none of the evaluated distributions adequately represented the behaviour of the analysed processes. Consequently, traditional probabilistic models were discarded, and $\bar{X}$-R control charts were used as a more suitable alternative for monitoring system stability without relying on normality assumptions, particularly given the variable and non-parametric nature of the observed data.

To investigate further the service time behaviour, a procedure was applied to estimate the underlying distributions. As shown in Table 6, for Process A, the exponential, gamma, and normal distributions were all rejected on the basis of their p-values:

Table 6: Goodness-of-fit test results for Processes A, E, F, L, V

Name	E(x)	Var(x)	p-value	Conclusion
Exponential dist.	13,433	180,445	0.000	Rejected
Gamma dist.	7,465	55,056	0.000	Rejected
Normal dist.	13,433	60,062	0.000	Rejected

Results for Process A

Name	E(x)	Var(x)	p-value	Conclusion
Exponential dist.	13,391	179,337	0.000	Rejected
Gamma dist.	7,904	50,563	0.000	Rejected
Normal dist.	13,391	59,598	0.000	Rejected

Results for Process E

Name	E(x)	Var(x)	p-value	Conclusion
Exponential dist.	5,789	33,515	0.000	Rejected
Gamma dist.	3,598	7,832	0.000	Rejected
Normal dist.	5,789	11,622	0.021	Rejected

Results for Process F

Name	E(x)	Var(x)	p-value	Conclusion
Exponential dist.	14,943	223,307	0.000	Rejected
Gamma dist.	8,830	79,479	0.000	Rejected
Normal dist.	16,473	90,440	0.021	Rejected

Results for Process L

Name	E(x)	Var(x)	p-value	Conclusion
Exponential dist.	16,472	271,350	0.000	Rejected
Gamma dist.	9,179	87,228	0.000	Rejected
Normal dist.	14,897	78,961	0.021	Rejected

Results for Process V

The **lack of proper fit** of traditional statistical distributions (exponential, gamma, normal) to the processing times in processes A, E, F, L, and V suggested that these processes exhibited inherent complexity or higher-than-expected uncontrolled variability. This might have reflected the presence of nonlinear factors, complex interactions between variables, or structural variability that could not be captured by conventional distribution models. Instead of focusing on finding an exact distribution model, which clearly did not fit the data, a more pragmatic and robust approach such as Six Sigma was adopted, which does not rely on a specific distribution. Rather, it focuses on optimising performance by reducing variability and continuously improving processes.

Six Sigma aims systematically to eliminate defects and reduce variability by using advanced statistical tools and a data-driven process management approach. Since it does not depend on fitting specific distributions, Six Sigma offers greater flexibility in managing and optimising processes, regardless of the underlying complexities. Using the DMAIC approach, it was possible to identify the sources of variability and to improve the processes to ensure that the processing times remained within the established specification limits.

In addition, implementing statistical process control, through tools such as control charts, allows for real-time monitoring of process behaviour. This helps to identify deviations or unusual fluctuations without the need to fit a standard probability distribution. This continuous control system provides greater insight into process stability and allows for quick, informed decisions to correct any deviation before it has an impact on product or service quality. In total, 32 theoretical distributions were evaluated using EasyFit® software. None of them provided a satisfactory fit for the data. Given this result, $\bar{X}$-R control charts were used to analyse the behaviour of service times in the different processes. Since the processes under study are classified as mass service processes, control charts are the most appropriate statistical tool for monitoring process stability and identifying potential variability. As a result, $\bar{X}$-R charts were developed for each process.

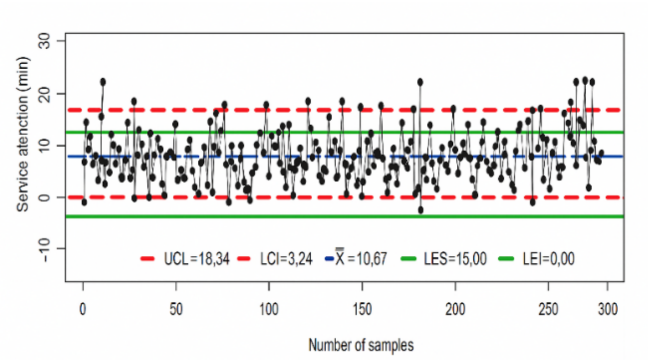

Figure 8: Control chart for process A $\underline{X}$

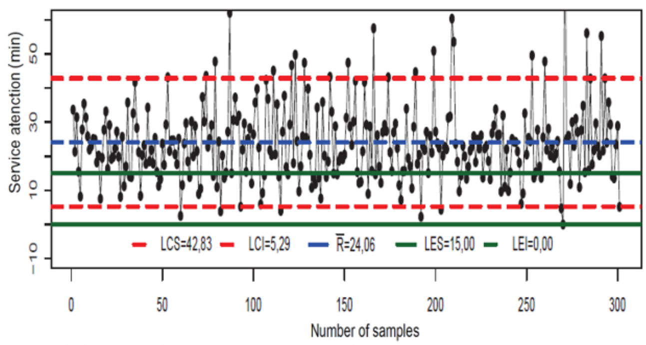

Figure 9: Control chart for process A R

In the control chart in Figure 8, it was observed that the service process – regardless of which one – was out of control. The control limits established for the processes are higher than the specification limits, and it is also common to observe points outside those specification limits. Regarding the ranges, a significant distortion was noted: instead of decreasing, the ranges under which service times occurred had expanded, indicating increased process variability.

For Process F, no observations were recorded during the final year because, since 2024, the shifts previously handled by Process F have been reassigned to Process A. To finalise the diagnosis, process capability indices were applied, and the corresponding results are shown in Table 7.

Table 7: Capacity indices

Process	C_p	C_{p_i}	C_{p_s}	C_{p_k}	K	C_{p_m}
A	0,26	0,36	0,15	0,15	40,69	0,15
F	0,26	0,39	0,13	0,13	49,28	0,14
L	0,22	0,35	0,08	0,08	62,10	0,10
V	0,23	0,35	0,11	0,11	51,68	0,11

Based on the capability indices, it was observed that the variation of the processes was too large relative to the specification limits. On average, the processes are not capable of meeting the required specifications. Regarding the actual capability index (Cpk), which considers process centering, a greater capability was found near the lower specification limit, while the capability near the upper limit was significantly lower. This indicated that, most of the time, the observations exceeded the upper specification limit. In addition to being incapable, the processes were off-centre, showing a clear tendency to fall outside the upper limit. The centering index (K) assessed how centred the process was within the specification range. With observed values exceeding 20%, it was confirmed that the processes were not centred.

Unlike traditional indices that consider tolerance intervals, the Taguchi capability index is more stringent in evaluating process performance. The values obtained using this index indicated very poor performance, showing that the process variation was too high to meet the company's value proposition.

3.3. Simulation of the customer service system

Using a simulation model built in JAAMSIM, the behaviour of the demand that the care system experiences daily was incorporated: the attention time according to the applied process, and the disposition of both physical and human resources and the disposition of the waiting line (Figure 10).

Figure 10: Simulated workstation

1 Corresponds to the representation of the human resource assigned to attend at the workstation.
2 Is an indicator of availability of care; if the indicator is green, then the station and the service staff are available to serve a client.
3 These objects, linked together, perform the operation of bringing together the client, the station, and the staffer; this set must be complete so that customer service can be performed.
4 In this object the customer service process is carried out.
5 These objects release the set formed before the customer service operation; the client is released after being served, and the station and service staff are available to serve another client.
6 These objects represent internal queues, although the client does not queue at the workstation in real life; these objects are necessary for the simulation model to function correctly.

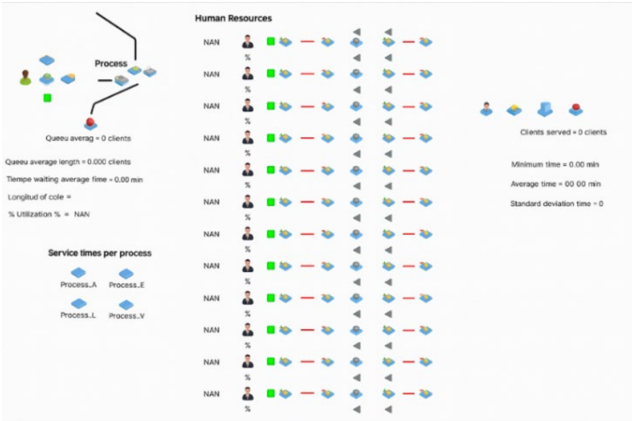

Figure 11: Representation of the system using a simulation model

To validate the operation, the absolute error rates were verified (Figure 12).

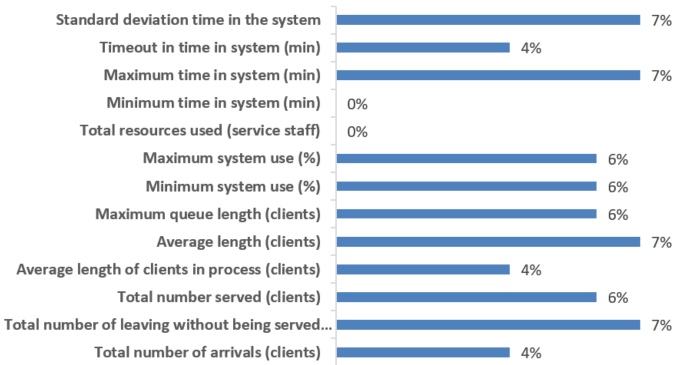

Figure 12: Absolute error rates between observed and simulated

The average error rate in demand (total number of arrivals) in Figure 12 shows an absolute error equal to 4% – that is, the simulated demand is similar to the observed demand. This same reasoning is applied to the other indicators; the maximum queue length is the one with the highest error rate of 8%; however, it is still valid. The simulated model represents the real system.

3.4. Evaluation of productivity improvement and increase

To identify the root causes and strategies, we applied the Ishikawa diagram or heavy spine (Figure 13).

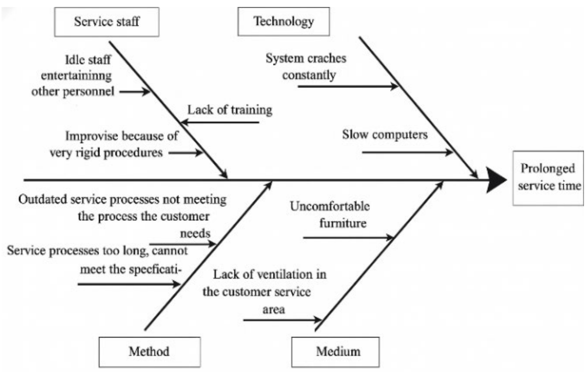

Figure 13: Ishikawa diagram

To mitigate the causes that affect attention time, the following strategies were established (Table 8):

Table 8: Association of causes and mitigation strategies

Causes	Strategies
Lack of training Rigid procedures Outdated processes	Correction of process instability and capacity
Very long processes	Set new specification limits
Unemployed staff	Human resource management
System failures Slow computers Uncomfortable furniture Lack of ventilation	Technical and administrative support

3.4.1. Correction of process instability

By taking into account the capacity indices shown in Table 7 and the control letters, the processes carried out in the customer service centre could be characterised as incapable and unstable.

To correct this behaviour, the following steps needed to be followed:

1 Identify reasons for the causes of instability with the involvement of supervisors and service staff.

2 Analyse the reasons identified in Step 1 against the administrative records to confirm the causes of the instability presented in each of the processes.

3 Standardise processes by making corrections after evaluating the reasons.

4 Train service staff in new methods and maintain a consistent customer-service attitude campaign.

5 Perform constant measurements, using the control letters for the processes, to identify whether the measures implemented have had a positive effect.

The standardisation of processes generated a 20% decrease in the variation of the process, with which the results were obtained (Figure 14).

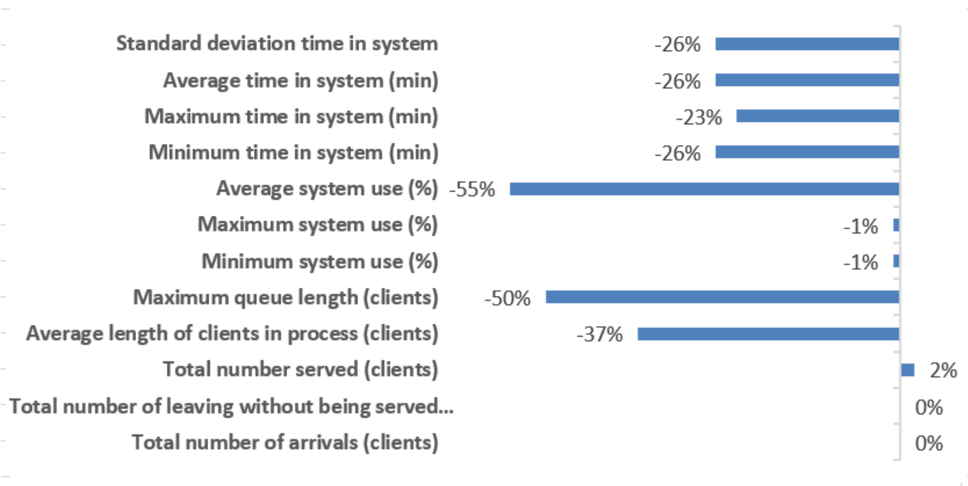

Figure 14: Variation after process standardisation

The variation after the processes had been standardised caused the productivity of the system to increase. Previously, 17 service staff had served 701 clients, but once this strategy had been applied it can be seen that the number of clients served reached 712. This represented an increase in productivity of 2% more customers served by the same staff.

3.4.2. Setting new specification limits

The company had previously established specification limits for the time that people remained inside the care centre: a maximum time (upper specification limit, USL) of 15 minutes and a minimum time (lower specification limit, LSL) of 0 minutes. However, there was no technical basis for how these limits were set. In other words, the service policy did not rely on a technical criterion such as a capacity analysis or a pilot test of the customer service system.

To identify the sensitivity of the capacity indices, a simulation was performed for Process A with the increased specification limits, which produced the following results (Table 9):

Table 9: Simulated capacity ratings for Process A

New limits	C_p	C_{p_i}	C_{p_s}	C_{p_k}	K	C_{p_m}
0 to 15.0	0,26	0,36	0,15	0,15	40,69	0,15
0 to 17.5	0,30	0,36	0,24	0,24	20,59	0,18
0 to 20.0	0,35	0,36	0,33	0,33	5,52	0,22
0 to 22.5	0,39	0,36	0,41	0,36	-6,21	0,24
0 to 25.0	0,43	0,36	0,50	0,36	-15,59	0,26

Although the objective was not to establish broad specification limits in order to cover the shortcomings of the system, establishing new limits would serve to validate the value offer without creating false expectations.

3.4.3. Human resource management

When a project is carried out, regardless of its nature, one of the most closely monitored indicators is cost optimisation. In the case of the evaluated system, the improvement would be accompanied by a reduction in human resources while continuing to serve customers adequately.

From the simulations that were performed, it was observed that simply eliminating extreme values in service times led to a notable improvement in the system. The minimum utilisation indicator shows that one operator was occupied 93.04% of the time on Monday, but only 39.83% on Friday – representing a 57% decrease in utilisation. This revealed the existence of unused capacity (Table 10).

Table 10: Impact of human resource management

Indicator	Friday (before)	Friday (after)	Variation
Average queue length	0,11	0,36	227%
Average timeout (min)	0,07	0,39	457%
Average system use (%)	80,50	88,86	10%
Resources used	17	16	-6%

A slight increase in total average use was observed, and this change did not affect the queue length – that is, the waiting time was not affected, except for Mondays, when the strategy would see an increase of one person. In one month, a total saving of 959 USD was achieved, and in the first year the cost decrease reached 11 508 USD. Therefore, the implementation of this strategy would produce favourable results for the company in increasing the use of the system and reducing costs.

This represented an increase in productivity of 6.28% with respect to personnel expenses; therefore, the optimisation of system expenses was achieved.

3.4.4. Technical and administrative support

To solve the problems associated with the environment in which customer service was carried out and with the technology, this strategy was developed to provide specific solutions to each problem:

- The system constantly went down: It would be necessary to carry out a review of the ways in which the operators connect to the internet, and to propose periodic preventive maintenance.
- Slow computers: Technical support people should be asked to perform maintenance of computers at both hardware and software levels.
- Uncomfortable furniture: It would be necessary to repair or replace furniture in a poor condition, and to provide related equipment to improve ergonomics.
- Lack of ventilation: A set of simple desktop fans should be incorporated to improve airflow at each workstation

By implementing all the improvement strategies, and assuming that the demand would not change and that there would be an increase in the number of customers being served following the implementation of the process standardisation strategy, and that personnel expenditure would decrease as a result of the improved administration of human resources, the following productivity was obtained (Table 11):

Table 11: Increased productivity

Strategy	Before	After	Increased productivity
Correcting process instability	41,23	41,88	1,57%
Human resource management	0,043	0,046	6,28%
Correction of process instability + Human resource management	0,043	0,046	7,76%

The strategy of establishing new specification limits did not contribute to productivity; however, this strategy directly affected capacity indices, and the administrative support strategy contributed to productivity. However, this would need to be measured after the implementation of the strategies to be able to quantify their impact.

3.5. Improvement plan proposal

In order to establish the guidelines for an improvement and control plan for the evaluated customer service system, the stages below should be followed.

Define the project: The problem is that the service centre is experiencing problems with the time taken to attend to clients; this caused people to wait, and the total time for which a client remains he system can easily exceed an hour. In addition, the value offering to customers of a maximum wait of 15 minutes is not met, because it causes them dissatisfaction.

The project is defined as follows:

Name of the project: Improvement of the customer service system.

Project leader: Customer service management.

Description of the problem: Long service times, which cause the client's waiting time to increase, thus extending the total time spent in the service centre.

Team members: Head of customer service, head of agency, shift supervisor, service staff.

Importance: Customers who wait long periods to be served gain an impressions of poor quality, in addition to feeling dissatisfied with the treatment they receive.

Objective: To reduce service times and waiting times for customers at the contact centre.

Constraints: Human resources cannot be increased because of space limitations; demand cannot be changed, so the system must adjust to it; and opening hours cannot be extended.

Deliverables: Staff training, monitoring tools and statistical control of processes, improvement of ergonomic conditions at workstations.

Resources: Supervision team, customer service team, administrative requirements (hardware, software, etc.).

Stakeholders: Customers, service staff, heads, and managers of quality and customer service.

Measure the current situation: To measure the process, a set of tools has been established:

- Control letters
- Process capacity indices
- Set of indicators associated with simulations

Analyse to identify the causes: For this section the Ishikawa diagram is used that identified the causes of the time taken to attend to clients.

Implement the solutions: The identified strategies are implemented to mitigate the causes of the problem with attending to customers in the system.

Control: All the statistical tools used serve to control the performance of the system.

This improvement plan must be applied until the system meets the specifications and delivers a quality service according to the client's requirements and the new value offer generated by the company.

4. DISCUSSION

The results of the study show that the current customer service system experiences high variability and a low ability to meet the established specification limits, which negatively affects the perceived quality of service. The simulation confirmed that process standardisation, along with improved human resource management, could increase productivity and significantly reduce waiting times. However, it was identified that the previously defined specification limits lacked technical support, suggesting that a redefinition based on the system's actual capacity would be essential to avoid creating unrealistic expectations. Moreover, although the technical and ergonomic support strategy did not show an immediate measurable impact on productivity, it could yield long-term benefits in staff satisfaction and performance. Overall, the implemented strategies should reinforce the need for a systemic, data-driven approach to continuous improvement in customer service environments.

5. FUTURE WORK

Based on the results obtained, several opportunities emerge to broaden the scope of this study. First, the development of predictive demand models using machine learning techniques – such as neural networks or ARIMA models (AutoRegressive Integrated Moving Average) – is proposed. These would allow real-time anticipation of fluctuations in customer flows and enable dynamic resource allocation, thereby enhancing system responsiveness.

In addition, it is suggested that the proposed model be replicated in other service centres, both in the CNT EP and in similar public institutions. Such replication would allow researchers to evaluate the generalisability of the approach, identify common patterns, and validate its applicability in different operational contexts.

Finally, follow-up studies are recommended to analyse the real impact of the improvement plan over the medium and long terms, taking into account both operational performance and financial indicators. These studies would help to establish more accurate cost-benefit relationships and to strengthen strategic decision-making for the continuous improvement of customer service systems.

6. CONCLUSIONS

The applied analysis supported the development of a monitoring and control plan for the studied system. It also established a new starting point to implement improvements. The average demand is 669 people, with a higher demand on Mondays, which generates longer queues, reaching up to 22 people waiting to be served, and a general rate of 5% of customers leaving before they have been served. System use reaches 100%, indicating an overload, although it drops to 86% on Fridays. The average waiting time is 7.67 minutes, and the total time that people spend in the system is 52.11 minutes.

The main resource of this system is the service staff; therefore, efforts must focus on providing them with adequate tools, practical customer service methods, a suitable environment, and ongoing training to ensure the sustainability of the improvements over time.

By implementing the improvement strategies, the average waiting time was reduced by 55%. This was also reflected in a 72% reduction in the average queue length; in other words, customers waited less and queues became shorter as a result of the improvements.

Customer service productivity relative to the number of service staff increased by 1.57% through process standardisation. By improving the use of human resources through effective management strategies, the productivity of serving customers per salary expenditure increased by 6.28%. When both strategies, serving more customers and reducing staff, were combined, productivity increased by 7.76%. More customers were served at a lower cost.

The service level was initially 20%. After implementing the process standardisation strategy, this indicator doubled to 40%. As a result, the number of customers served within the specification limits increased from 147 to 298.

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