The Role of Waiting Lines in Decision-Making – A Field Study of the National Social Security Fund for Salaried Workers in El Oued, Algeria

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Received: 02/10/2023 Accepted: 05/12/2023 Published: 16/12/2023

Abstract

This study aims to explore the role of waiting lines in the decision-making process. The applied aspect of the study focuses on assessing the extent to which the Social Security Institution utilizes the waiting line model and its effectiveness in aiding decision-makers at the National Social Security Fund for Salaried Workers in El Oued. This led to addressing the core research question: What is the role of waiting lines in decision-making?

Among the findings of this study, we identified a lack of utilization and application of waiting line models in decision-making within the institution under study, as well as a shortage of specialists in this field. Based on these findings, several recommendations can be proposed, including establishing specialized centers for waiting line management, ensuring the availability of all necessary material, technical, and human resources to provide consultancy in this area, and improving the decision-making process. Additionally, efforts should be made to raise awareness of the importance and benefits of applying waiting line methods in decision-making through seminars, conferences, and open sessions.

Keywords: Operations research, decision-making, waiting lines.

Regul Sci. ™ 2023; 9(2): 3832 - 3851

DOI: doi.org/10.18001 /TRS.9.2. 245

1. Introduction

The theory of waiting lines serves as an analytical tool that helps managers systematically compare alternatives and make optimal decisions. In this paper, we examine how to determine the characteristics that measure the performance of a service system operating under random conditions, which lead to the formation of queues.

To illustrate the structure and key attributes of a queuing system, we consider an employee who takes customer orders and then fulfills them before moving on to the next customer, continuously repeating the process. This represents a single waiting line. It is often observed that customers may arrive at a rate faster than employees can serve them. In such cases, queues form, and some customers may leave without receiving service if no waiting space is available.

1.1 Research Problem

In this context, the following research question arises:

"Does the queuing system contribute to the decision-making process in the institution under study?"

This main question is further divided into the following sub-questions:

1. Is the time customers spend in the system (Social Security Institution) an indicator of the emergence of waiting lines?
2. Do customers spend long periods in queues before receiving service?
3. Can queuing theory propose an optimal waiting model?
4. What type of distribution governs customer arrival times?
5. What type of distribution governs service times?

1.2 Research Hypotheses

Based on the research problem and questions, the main hypothesis is:

"The queuing system contributes to the decision-making process in the institution under study."

This main hypothesis leads to the following sub-hypotheses:

- The time customers spend in the system is an indicator of congestion and the emergence of waiting lines.
- Customers spend long periods in queues before receiving service.
- The optimal model is the one that ensures high-quality service.
- Customer arrivals follow a Poisson probability distribution.
- Service time follows an exponential distribution.

1.3 Research Objectives

The primary objectives of this study are as follows:

- Optimize resource utilization at both the national and organizational levels to prevent resource wastage and maximize financial returns on investments.
- Assist management in making optimal decisions by considering decision-making as both a science and an art. It is a science because it provides mathematical and algebraic tools to solve decision-making problems.
- Identify and analyze operations research models for quantitative analysis to help management make optimal decisions.

1.4 Research Scope

To better define the research problem and achieve the study's objectives, the scope of this research is outlined as follows:

1.4.1 Thematic Scope

The study focuses on queuing systems and decision-making.

1.4.2 Spatial Scope

The study is applied to a selected sample within the institution under study.

1.4.3 Temporal Scope

The study is conducted starting from the beginning of the academic year, covering both theoretical and field research phases.

1.5 Research Methodology

To answer the research questions and test the hypotheses, we adopt a descriptive-analytical approach. This involves collecting information through literature reviews, including primary and secondary sources, as well as articles in economics, management, and human resource management.

For the applied aspect, we employ a case study approach to apply theoretical insights to the reality of the institutions under study. This allows us to assess the role of operations research in decision-making based on institutional data, official documents, reports, and interviews conducted with employees.

2. Theoretical Framework of the Social Security Institution

The national social protection system of any country reflects its level of social and economic development. It also serves as an indicator of the level of consultation among economic, social, and political actors. Social security plays a crucial role in safeguarding workers and their families, contributing positively to national income and economic stability, both in Algeria and globally.

2.1 Concept of Social Security

In Algeria, social security is an integral part of the worker's and their family's immediate environment. Since its establishment, the Algerian social security system has undergone continuous and intensive development, particularly since the country's independence in 1962. Significant improvements have been made, particularly in expanding social protection coverage to include a broader segment of the population and simplifying procedures to ensure access to social security benefits.

2.1.1 Definition of Social Security

Social security is defined as:
"Programs managed by the government or the responsible authority in society to provide care for

the population through necessary measures that ensure access to essential resources such as food, housing, healthcare, and general protection. The primary beneficiaries of social security services include young children, the elderly, the sick, and the unemployed. The services provided by social security are referred to as social services." (Ibrahim Abdel Mohsen Haggag, 2019, p. 79).

Social security is also known as social insurance, as it provides benefits and services such as retirement pensions, disability insurance, unemployment compensation, and all government-provided services or those offered by authorized social security agencies. These services include financial support in the form of compensation, medical services, and various aspects related to healthcare and social work.

Social security plays a significant role in all societies by providing essential social services to individuals and communities. The key services include:

- Providing a monthly pension to insured workers upon retirement.
- Offering financial compensation to individuals in cases of unemployment or inability to work due to disability or chronic health conditions.
- Ensuring economic protection for all workers, particularly those who reach old age and can no longer work.
- Providing a monthly pension to the families of deceased insured individuals to support them financially after their loss.
- Creating job opportunities for the unemployed through new projects or job placement programs.
- Enhancing psychological stability within society.

2.1.2 Major Social Security Laws in Algeria

The key social security laws in Algeria include: (Jusoor Al-Tawasul, 2013, p. 5)

- **Law No. 11-83**, related to social insurance, enacted on July 2, 1983.
- **Law No. 12-83**, concerning retirement, enacted on July 2, 1983.
- **Law No. 13-83**, regarding occupational diseases and work-related accidents, enacted on July 2, 1983.
- **Law No. 14-83**, outlining the obligations of individuals receiving social security services, enacted on July 2, 1983.
- **Law No. 15-83**, governing disputes in the field of social security, enacted on July 2, 1983.

The 1983 social security laws contributed to social development and served as a vital instrument for social solidarity. They are characterized by the following:

- Unifying systems based on the principles of solidarity and redistribution.

- Mandatory enrollment for all salaried workers, self-employed workers, and similar categories. Additionally, enrollment is compulsory for specific groups classified as special categories.
- Standardizing regulations concerning the rights and obligations of beneficiaries.
- Unifying the financing process.

The system covers all branches of social security stipulated in international agreements, including maternity insurance, disability insurance, death benefits, work accident and occupational disease coverage, retirement (old-age insurance), unemployment insurance, and family benefits.

2.2 Responsibilities of the National Social Insurance Fund for Salaried Workers

The **National Social Insurance Fund for Salaried Workers (CNAS)** is the main body responsible for Algeria's general social security system. It provides social insurance services to over **20 million insured individuals and beneficiaries**, making it the cornerstone of social security in Algeria. CNAS reflects the broader social security system and plays a crucial role in shaping the country's social policies. (www.cnas.dz, 2020).

Although social security institutions are public entities, the legislator has entrusted their management to administrative councils in line with the principle of self-governance. This approach aligns with the political and economic transformations Algeria has experienced.

Under the applicable laws, CNAS is responsible for the following tasks: (Article 8 of Executive Decree No. 92-07, 1992, p. 12)

- Managing in-kind and cash benefits related to social insurance, work accidents, and occupational diseases.
- Administering family benefits.
- Ensuring the collection, monitoring, and dispute resolution of contribution payments that fund benefits.
- Contributing to the promotion of workplace accident prevention policies and occupational health measures.
- Managing benefits for individuals covered under international social security treaties and agreements.
- Organizing, coordinating, and conducting medical supervision.
- Implementing health and social projects.
- Carrying out awareness campaigns related to prevention, education, and public health information.
- Managing the Social Insurance Assistance and Relief Fund.

- Assigning national registration numbers to insured individuals and employers.

3. Problem Statement and Mathematical Formulation

The purpose of presenting the research problem is to find a solution. It serves as the foundation that enables the researcher to gather the necessary information and data, analyze the problem, and formulate hypotheses to reach a logical solution. This is achieved by obtaining meaningful results and providing useful recommendations through the application of systematic and scientific methodologies.

3.1 Problem Definition

Due to the increasing demand for various services, queuing problems have become a pressing issue in multiple fields. Service managers often find themselves in a dilemma between maintaining the current state to control costs—at the risk of losing customers and damaging their reputation—and adding new service centers, which entails additional expenses.

Queue formation occurs when the rate of service requests exceeds the rate at which service centers can provide them. In such cases, service seekers typically aim to obtain their requests in the shortest possible time. Likewise, service providers share this interest, as prolonged wait times can lead to customer dissatisfaction and loss of loyalty.

This necessitates the use of an **Operations Research** technique for decision-making, which, in this study, is queuing theory.

3.1.1 Model Development and Formulation

At this stage, the real-world problem is examined and translated from an **economic framework** into a **mathematical model** based on structured steps. These steps are necessary to develop the mathematical model of the problem in preparation for its solution.

3.1.1.1 Representation of the Queuing Phenomenon in Social Security Service Centers

The queuing system at the selected service center consists of **service-seeking units**, represented by customers arriving from an **unlimited population**. These customers enter the queue and wait for their turn to receive service. The **priority rule** in this system follows the **First-Come, First-Served (FCFS)** principle. After receiving the service, the customer exits the system.

It is important to note that queuing occurs in service centers because the **arrival rate** of customers is **higher** than the **service rate** provided by the center.

3.1.1.2 Components and Characteristics of the Queuing System

- The arrival of customers to the queue is **random**, meaning some may arrive simultaneously while others arrive individually (the latter being more common).
- The **arrival time** of customers and the **service time** cannot be predicted.
- In this study, the **queue length is unlimited**, meaning that no maximum limit is set for waiting customers.

- The queuing system under consideration consists of **a single queue**.
- The service discipline follows the **First-Come, First-Served (FCFS)** principle.

3.2.1. Statistical Information on the Queuing System

- Service operations run **continuously** from **8:00 AM to 12:00 PM** in the morning, and in the afternoon, the institution continues to receive customers for service, regardless of their numbers, as long as they arrive during official working hours.
- This indicates the presence of an **unlimited (infinite) number** of service seekers.

3.2.1.1. Observation Period Determination

The study period was set to **eight weeks**, extending from **May 21 to July 20**. Observations were recorded on the institution's **working days (Sunday to Thursday)**. The summary of observation periods is presented in the following table:

Table 1: Observation Period Determination

Day of the Week	Observation Hours	Observation Duration (minutes)	Observation Sessions per Week
Sunday	9:00 - 12:00	180 min	18
Monday	9:00 - 12:00	180 min	18
Tuesday	9:00 - 12:00	180 min	18
Wednesday	9:00 - 12:00	180 min	18
Thursday	9:00 - 12:00	180 min	18

Source: Prepared by the researchers.

3.2.1.2. Customer Arrival Time Determination

To analyze customer arrivals to the queue at **unequal time intervals**, 120 observation sessions were conducted during the study period. The **arrival rate (λ)**, which represents the average number of customers arriving per **10-minute interval**, was calculated using the following data table:

Table 2: Customer Arrival Time Determination

Number of Arriving Customers	0	1	2	3	4	5	6	7	8	9	Total
Observed Frequency	2	4	4	3	33	24	12	9	11	18	120
Total Count	0	4	8	9	132	120	72	63	88	162	

Source: Prepared by the researchers.

3.3 Presentation and Discussion of Results

To determine the **average number of customers arriving** at the **service centers** of the **Social Security Institution, Oued Agency**, the study period was set at **eight weeks**, spanning from **May 21, 2020, to July 20, 2020**. Observations were conducted on the **working days** of the service office, from **Sunday to Thursday**, resulting in a **total observation period of forty days.**

Each observation day included a **three-hour morning session**, from **9:00 AM to 12:00 PM.** A total of **120 samples** were collected, corresponding to **120 observation periods**, each lasting **10 minutes.** These samples were analyzed to study and evaluate the issue of **queue formation** within the institution.

3.3.1 Statistical Study of Customer Arrival Time

The **arrival process** of customers plays a **crucial role** in **queuing theory**, particularly in analyzing the **irregular arrival patterns** at the **Social Security Institution**. Since customers arrive at **unequal time intervals**, identifying the **probability distribution** governing this phenomenon was necessary.

To achieve this, a **sample of 120 time periods** was selected, with each period set at **10 minutes**. Based on these observations, the **arrival rate (λ)**—which represents the **average number of customers arriving within a 10-minute interval**—was determined using the following dataset:

Table 3: Distribution of Customer Arrivals During the Observation Period

Number of Arriving Customers (xi) per Time Interval	0	1	2	3	4	5	6	7	8	9	Total
Observed Frequency (Fobs)	6	24	34	28	12	7	3	4	2	1	120
Total Count (xi * Fobs)	0	24	68	84	48	35	18	28	16	9	330

Source: Prepared by the researchers.

3.3.1.1 Calculation of Arrival Rate (λ)

The arrival rate **λ** is calculated using the **arithmetic mean formula** as follows:

$$\lambda = \frac{\sum_{i=1}^{9} Fobs\,(i) * xi}{\sum_{i=1}^{9} Fobs\,(i)}$$

Where:

- **λ**: The arrival rate per **time interval** (10 minutes).
- **Fobs**: The observed absolute frequencies.
- **xi:** The number of arriving customers per **10-minute interval.**

The arrival rate is calculated as follows:

$\lambda = \frac{330}{120} = 2.75$

Since each time interval is **10 minutes**, the arrival rate per **minute** is:

$\lambda = \frac{2.75}{10}$

Thus, the **customer arrival rate** is: (λ=0.275 customers/minute)

3.3.1.2. Conducting the Khi-Square (χ^2) Test on Arrival Time Distribution

After calculating the **arrival rate (λ)**, we will test whether the arrival distribution follows a **Poisson distribution**. This test, known as the **Khi-Square (χ^2) Test**, compares the observed frequencies with the theoretical frequencies calculated based on Poisson's law.

The **Khi-Square (χ^2) formula** is given by:

$$\chi^2 = \sum_{i=1}^{n} \frac{[\ Fth(i) - Fobs(i)\ ]^2}{Fth(i)}$$

Where:

- **Fobs(i)**: The observed absolute frequencies.
- **Fth(i)**: The theoretical absolute frequencies, which are obtained using the **Poisson probability formula** and multiplying the results by the **total observed frequency**:

Where:

$$\sum_{i=1}^{9} Fobs(i)\,] * e^{-\lambda} \;\; Fth = [\ \frac{\lambda^x}{x!}$$

- **Fobs(i)**: The observed frequency for variable **i**.

Hypotheses for the Khi-Square Test

In our study, we conduct the **Khi-Square test** to verify whether the arrival of customers at the **Social Security Agency** follows a **Poisson distribution**. The hypotheses are as follows:

- **H_0 (Null Hypothesis):** Customer arrivals follow a Poisson distribution.
- **H_1 (Alternative Hypothesis):** Customer arrivals do not follow a Poisson distribution.

The calculations are summarized in the table below:

Table 4: Khi-Square (χ^2) Calculation for Customer Arrivals

iii	Theoretical Frequency (Fth)	Observed Frequency (Fobs)	(Fobs−Fth)2(F_{\text{obs}} F_{\text{th}})^2(Fobs−Fth)2	- Khi-Square Value (χ^2)
0	7.6713	5	7.1361	0.9302
1	21.0962	24	8.4321	0.3997
2	29.0073	34	24.9274	0.8593
3	26.5900	28	1.9881	0.0748
4	18.2806	12	39.4462	2.1578
5	10.0543	7	9.3290	0.9279
6	4.6082	3	2.5864	0.5613
7	1.8104	4	4.7944	2.6483
8	0.6223	2	1.8980	3.0499
9	0.1902	1	0.6559	3.4491
Total	-	**120**	-	**15.0583**

Source: Prepared by the researchers.

To determine the extent to which the studied phenomenon conforms to the **Poisson distribution**, we compare the calculated **Khi-Square (χ^2)** value with the tabulated **Khi-Square (χ^2)** value. For this, we first calculate the **degree of freedom (v)** using the formula:

V=c−m−1V = c - m - 1V=c−m−1

Where:

- **V**: Degree of freedom
- **c**: Number of variables
- **m**: Number of parameters in the distribution (in this case, we have one parameter, **λ**)

Thus, the degree of freedom is:

V=10−1−1=8V = 10 - 1 - 1 = 8V=10−1−1=8

By referring to the **Khi-Square (χ^2) table** at a **5% significance level** ($\alpha = 0.05$) and **8 degrees of freedom**, we obtain the tabulated Khi-Square value:

χ(0.05,8)2=15.507\chi^2_{(0.05, 8)} = 15.507χ(0.05,8)2=15.507

Now, by comparing the **calculated Khi-Square value** (**χ^2_cal** = **15.058**) with the **tabulated Khi-Square value** (**χ^2_tab** = **15.507**) at a **5% significance level** and **8 degrees of freedom**, we find that the tabulated value is **greater** than the calculated value.

Since **χ^2_tab (15.507) > χ^2_cal (15.058)**, we **fail to reject the null hypothesis (H_0)**. This means that the **observed arrival distribution of customers can be approximated by the theoretical Poisson distribution** at a **5% significance level**, with the estimated parameter:

λ=0.275 customers per minute

3.4. Statistical Study of Service Time

Service time refers to the duration a customer spends at the service center until their request is completed and they leave. The total observation period is **8 weeks**, from **May 21, 2020, to July 20, 2020**. We follow the same statistical study steps as the **arrival time analysis**, observing the service time for each customer from their arrival at the **single service center** until their departure. The total study period is considered, and we then calculate the **absolute frequencies** corresponding to the service times. To do so, we need to determine the **number of intervals and their length.**

3.4.1. Determining the Number of Intervals

After analyzing the **service times** during the study period, we found that they range between:

- **Maximum value: 8 minutes**
- **Minimum value: 1 minute**

To determine the **number of intervals (K)**, we use **Sturges' formula:**

$K = 1 + 3.322 \log_{10} n$

Where:

- **K** = Number of intervals
- **n** = Number of observations

By substituting our values into **Sturges' formula:**

$K = 1 + 3.322 \log_{10} 120 = 7.907 = 8$

To find the **interval length (T)**, we divide the **range** by the **number of intervals (K)**:

$T = \frac{8-1}{8} = 0.875$

3.4.2. Distribution of Customer Service Times

From the above, we have **8 intervals of length 0.875 minutes**. The following table summarizes the statistics and allows us to calculate the **average service time:**

Table (05): Distribution of Service Times for Customers of the Social Security Institution (Oued Souf Agency) from May 21 to July 20, 2020

Service Time (minutes)	Observed Frequency Fobs (Number of Customers Served)	Class Midpoint Ci	Midpoint Frequency Product (Ci * Fobs)
(1.000 - 1.875]	28	1.4375	40.25
(1.875 - 2.750]	25	2.3125	57.8125
(2.750 - 3.625]	19	3.1875	60.5625
(3.625 - 4.500]	15	4.0625	60.9375
(4.500 - 5.375]	12	4.9375	59.25
(5.375 - 6.250]	9	5.8125	52.3125
(6.250 - 7.125]	7	6.6875	46.8125
(7.125 - 8.000]	5	7.5625	37.8125
Total	**120**	-	**415.75**

Source: Prepared by the researchers.

3.4.3. Calculation of Service Time

From the table, we can calculate the **average service time** (α) as follows:

$$\boldsymbol{\alpha} = \frac{\sum_{i=1}^{8} Fobs(i) * Ci}{\sum_{i=1}^{8} Fobs(i)}$$

Where:

- **α** = Average service time
- **Fobs(i)** = Observed frequencies for class i
- **C_i** = Class midpoint for class i

Calculating:

$$\alpha = \frac{415.75}{120} = 3.464583$$

Thus, the average service time (α) is **3.464583 minutes** per customer, from which we can derive the **parameter of the exponential distribution** equal to the reciprocal of the average service time:

$$\mu = \frac{1}{\alpha}$$

4.2.2. Conducting a Chi-Square Test on the Distribution of Service Times for Customers

After calculating the parameter of the exponential distribution (μ), we will conduct the Chi-Square test, which allows us to adjust the distribution of service times according to the exponential distribution. To verify that the service times follow the exponential distribution, we will use the Chi-Square test and follow the same steps as for the **arrival times test**, comparing the theoretical frequencies with the observed frequencies using the following relationship:

$$\chi^2 = \sum_{i=1}^{n} \frac{[Fth(i) - Fobs(i)]^2}{Fth(i)}$$

Where:

- **F_{th}(i)** = Represents the theoretical absolute frequencies, obtained using the mathematical relationship for the **Poisson distribution**, multiplied by the total observed frequencies as follows:
- $Fth = [\mu * e^{-\mu t}] * \sum Fobs$
- **F_{obs}** = Represents the observed absolute frequencies.
- **μ** = The parameter of the distribution, which equals the reciprocal of the average service time.

Calculating μ:

$$\mu = \frac{1}{\alpha}$$

In the same manner, we will apply the **Chi-Square test** to determine the theoretical distribution of the observations based on the following hypotheses:

- **H0**: The distribution of service times for customers at the institution follows the exponential distribution.
- **H1**: The distribution of service times for customers at the institution does not follow the exponential distribution.

The calculations for the Chi-Square test for service times can be summarized in the following table:

Table 06: Chi-Square Calculations for Service Times

Service Time xi	Class Midpoints Ci	Observed Absolute Frequencies Fobs(i)	Theoretical Absolute Frequencies Fth(i)	[Fth(i) – Fobs(i)]²	Calculated χ2
[1.000,1.875]	1.4375	28	22.93679493	25.63604554	1.117682118
[1.875,2.750]	2.3125	25	17.79633232	51.892828	2.915928241

Service Time xi	Class Midpoints Ci	Observed Absolute Frequencies Fobs(i)	Theoretical Absolute Frequencies Fth(i)	[Fth(i) – Fobs(i)]²	Calculated χ2
[2.750,3.625]	3.1875	19	13.80792064	26.9576881	1.952335098
[3.625,4.500]	4.0625	15	10.71336885	18.37520662	1.715166058
[4.500,5.375]	4.9375	12	8.312350217	13.29876092	1.635970642
[5.375,6.250]	5.8125	9	6.449434076	6.505386533	1.008675454
[6.250,7.125]	6.6875	7	5.00402399	3.983920232	0.796143311
[7.125,8.000]	7.5625	5	3.882550903	1.248692485	0.321616513
Total		**120**		**11.46351744**	

Source: Prepared by the researchers based on the program outputs.

To compare the calculated Chi-Square value with the tabulated value, we must calculate the **degrees of freedom** v as follows:

v=c–m–1

By substituting the corresponding numerical values, we find:

v=8–1–1=6

Referring to the Chi-Square table for v=6at a significance level of 5%, we find the tabulated Chi-Square value:

χ0.05,62=12.592

Comparing this with the calculated value χcal2=11.463, it is clear that the tabulated value is significantly greater than the calculated value. Therefore, we will accept the null hypothesis H0, meaning that the distribution of times in our study follows the exponential distribution for customer service at a significance level of 5%, where the previously calculated parameter is μ=0.29 services per minute.

3.5. Presentation and Discussion of Queueing Results Using the QM Program

Since the statistical study of the arrival phenomenon follows a Poisson distribution and the statistical study of the service phenomenon follows an exponential distribution, we will proceed by identifying the appropriate queueing model that represents the studied phenomenon, calculating its key performance indicators, and then proposing an alternative model to address the congestion issue.

3.5.1. Presentation of Results Under the Current System (M/M/1)

The performance indicators are calculated using the **Windows QM** application by selecting the appropriate queueing model, clicking on **M/M/1**, and entering the values of **λ** (arrival rate) and **μ** (service rate).

3.5.1.1: Results of the M/M/1 Queueing Model Test

After inputting the necessary data into the QM program, the following results are obtained, as shown in the table below:

Table (07): Results of the M/M/1 Queueing Model Test

Metric	Value	Metric	Value
M/M/1		**Average service utilization**	0.95
Arrival rate (λ)	0.28	**Average number in queue (Lq)**	17.39
Service rate (μ)	0.29	**Average number in system (L)**	18.33
Number of service centers	1	**Average waiting time in queue (Wq)**	63.22
		Average time in system (W)	66.67
		Probability of an idle system (P_0)	0.05

Source: Prepared by the researchers based on QM program outputs.

From the table, we derive the following conclusions:

1. The probability that customers are present in the system is **P = 0.95**, meaning there is a 95% chance that the system is occupied, indicating significant queue congestion.
2. The average number of customers in the queue is Lq = 17.39.
3. The average number of customers in the system is L = 18.33 customers.
4. The average waiting time in the queue is Wq = 63.22 minutes per customer.
5. The average time spent in the system is W = 66.67 minutes per customer.
6. The probability of the system being idle is P_0 = 0.05.

The current **queueing system status** for customer arrivals in the organization can be summarized in the following table:

Table (08): Current Queueing System Status in the Organization

Metric	Value
Customer arrival rate (λ)	0.275 customers per minute
Service rate (μ)	0.29 services per minute
Number of service centers	1
Probability of a busy service center	0.95
Average number of customers in the system (L)	18
Average number of customers in the queue (Lq)	17
Expected time per customer in the system (W)	66 minutes
Expected waiting time per customer in the queue (Wq)	63 minutes

Source: Prepared by the researchers

3.5.2. Presentation of Results Under the Proposed Model (M/M/2)

The researcher proposed adding a **new service center**, modifying the queueing system so that the only change in the model is the number of service centers, which now increases to 2, while keeping all other characteristics unchanged.

3.5.2.1. Characteristics of the Proposed Model (M/M/2)

- The service system follows a First-Come, First-Served (FCFS) discipline.
- The arrival distribution of customers in the new model still follows a Poisson distribution.
- The service time distribution in the new model remains exponentially distributed.
- Customer arrival rate (λ) = 0.275.
- Service rate (μ) = 0.29.

3.5.2.2. Presentation of Results Under the New Model

After entering the new parameters into the **QM** software, the results are processed as shown in the following table:

Table (09): New Queueing Model Performance Indicators After Adjustment

Metric	Value Metric	Value
M/M/2	**Average service utilization**	0.47

Metric	Value	Metric	Value
Arrival rate (λ)	0.28	Average number in queue (Lq)	0.28
Service rate (μ)	0.29	Average number in system (L)	1.22
Number of service centers	2	Average waiting time in queue (Wq)	1
		Average time in system (W)	4.45
		Probability of an idle system (P_0)	0.36

Source: Prepared by the researchers

6.3. Study of the Probability of Customers in the System (M/M/2)

The status of the alternative queueing system for customer arrivals in the organization can be summarized in the following table:

Table (10): Status of the Alternative Queueing System in the Organization

Metric	Value
Customer arrival rate (λ)	0.275 customers per minute
Service rate (μ)	0.29 services per minute
Number of service centers	2
Probability of a busy service center	0.47
Average number of customers in the system (L)	0.28
Average number of customers in the queue (Lq)	1.22
Expected waiting time per customer in the queue (Wq)	1 minute
Expected time per customer in the system (W)	4.45 minutes

Source: Prepared by the researchers

3.7. Discussion of Results

Based on the previous results and QM program outputs, we have found the following:

3.7.1. Current System Used in the Organization (M/M/1)

The current system produced the following results:

1. The probability of customers being in the system is P = 0.95, meaning the system (queue + service center) is occupied 95% of the time. This high percentage indicates severe congestion, putting excessive pressure on the single service center.

2. The number of customers in the system reaches 18, with one customer in the service center and the remaining 17 customers in the queue, creating significant congestion and excessive workload for the service employee.

3. The average time spent in the system is 66 minutes, of which the customer spends 3 to 4 minutes in service and approximately 63 minutes waiting in the queue. This long waiting time leads to customer dissatisfaction, frustration, and in some cases, customers abandoning the service or postponing it to a later time.

3.7.2. Proposed Model for the Organization (M/M/2)

The proposed model produced different results from the current system, summarized as follows:

1. The probability of customers being in the system is P = 0.47, meaning the system (queue + service center) is occupied 47% of the time. This percentage is considered acceptable, as it indicates that customers are present but without congestion. Additionally, the probability of an idle system is 36%, suggesting that at times, there may be no queue at all.

2. The number of customers in the system ranges from 1 to 2, with both customers being served in the two service centers, leaving the queue empty. This means that customers receive service immediately upon arrival without having to wait.

3. The average time spent in the system is 4.45 minutes, with 3 to 4 minutes in service and at most 1 minute in the queue. This significant reduction in waiting time leads to higher customer satisfaction.

3.7.3. Comparison of the Alternative Model with the Current System

Adding a new service center resulted in **positive changes**, improving key performance indicators in the desired direction. The main improvements in the new model are:

1. The probability of a busy system decreased from 0.95 to 0.47, meaning congestion has significantly improved. This reduction also allows service center employees to experience less pressure, especially during peak hours in the morning.

2. The average number of customers in the queue dropped from 17 to 1, and sometimes even to zero, indicating a remarkable reduction in queue length.

3. The average waiting time in the queue decreased from 63 minutes to just 1 minute. A customer who previously spent 66 minutes in the system (waiting + service) can now complete their service in less than 5 minutes. This significant improvement enhances customer satisfaction and demonstrates the success of the study and the effectiveness of queueing theory in optimizing service operations.

4. Conclusion

The National Social Security Fund for Salaried Workers (CNAS) in Oued Souf is the only institution in the region responsible for handling key customer services. As a result, it experiences high and continuous customer inflow, leading to queue congestion, particularly due to the presence of a single service center. This situation negatively impacts waiting times and overall customer satisfaction.

To enhance service quality and meet customer needs, queueing models were applied to analyze and resolve the congestion problem at CNAS in Oued Souf. The main objective of this study was to implement a quantitative approach that supports decision-making scientifically, using queueing theory to address customer congestion and find the optimal solution.

The study proposed a solution involving the addition of a new service center to improve service efficiency. The queueing theory model provided a scientifically grounded approach to reducing the long waiting times experienced by customers. The findings confirmed that introducing an additional service center could reduce the total service time per customer to less than five minutes. This reduction significantly improves customer satisfaction, as the queue shrinks to one customer or sometimes disappears entirely. These positive results validate the success of the alternative model, which should be presented to decision-makers for implementation to eliminate congestion at the institution.

4.1 Key Findings of the Study:

1. Limited use of queueing models in decision-making within the studied institution.

2. Shortage of specialists in this field.

3. Lack of awareness regarding the importance and applications of queueing models.

4.2 Recommendations:

1. Establish specialized centers focused on queueing systems, ensuring adequate financial, technical, and human resources to enhance decision-making processes.

2. Raise awareness about the benefits of queueing models through seminars, conferences, and open discussion panels.

3. Utilize computer applications related to Operations Research, such as Lindo, Win QM, and Win QSB, to assist business owners in making optimal decisions for project execution.

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