THE APPLICATION OF QUEUING THEORY TO IMPROVE QUALITY OF SERVICE PRESENTED BY CNEP BANK - JIJEL AGENCY

Abdelhak **ALIOUNE***

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Corresponding authors: abdelhak.alioune@univ-jijel.dz

ABSTRACT

This study aims to explore the impact of applying queuing theory in administrative decision-making in the Banking sector to tackle the issue of long waiting time for customers, in one of CNEP Bank (JIJEL agency, Algeria). Key conceptual frameworks were addressed for research variables, using the software (QM Windows) for analyzing different data, and the study was conducted from January 20, 2023 to February 7, 2023.

The result of the research and analysis showed that the application of the Queuing Theory helps in making sound administrative decisions related to reducing waiting time in the studied Bank branch.

Key words: Queuing Theory, Administrative Decision, CNEP Bank – Jijel Agency, QM Windows.

Jel classification : C44, C60, M100.

* University of Jijel, abdelhak.alioune@univ-jijel.dz, Algeria.

تطبيق نظرية صفوف الانتظار لتحسين جودة الخدمة المقدمة من قبل البنوك – دراسة حالة وكالة الصندوق الوطني للتوفير والاحتياط لولاية جيجل

ملخص

هدفت هذه الدراسة لمعرفة أثر تطبيق نظرية صفوف الانتظار في اتخاذ القرارات الإدارية بقطاع البنوك وهذا لمعالجة مشكلة الانتظار الطويل للزبائن، حيث تمت الدراسة بأحد فروع بنك CNEP (وكالة جيجل بدولة الجزائر)، تم تناول أهم التصورات الفكرية لمتغيرات البحث، مع استخدام برنامج (QM Windows) لتحليل مختلف البيانات المتحصل عليها، وقد طبقت هذه الدراسة خلال الفترة الممتدة من: 20 جانفي 2023 إلى 05 فيفري 2023.

بعد البحث والتحليل تم التوصل في الأخير إلى أن تطبيق نظرية صفوف الانتظار يُساعد في اتخاذ القرارات الإدارية السليمة المتعلقة بخفض زمن انتظار العملاء بالبنك محل الدراسة.

الكلمات المفتاحية: نظرية صفوف الانتظار، اتخاذ القرارات، CNEP بنك وكالة جيجل، QM Windows.

تصنيف جال: C44, C60, M100.

L'APPLICATION DE LA THÉORIE DES FILES D'ATTENTE

POUR AMÉLIORER LA QUALITÉ DE SERVICE PRÉSENTÉ PAR CNEP BANK - AGENCE DE JIJEL

Cette étude vise à explorer l'impact de l'application de la théorie des files d'attente dans la prise de décision administrative dans le secteur bancaire, afin de résoudre le problème du long temps d'attente des clients, dans l'une des agences de la Banque CNEP (agence de Jijel, Algérie). Des cadres conceptuels clés ont été abordés pour les variables de recherche, en utilisant le logiciel (QM Windows) pour analyser différentes données. L'étude a été menée du 20 janvier 2023 au 7 février 2023. Les résultats de la recherche et de l'analyse ont montré que l'application de la théorie des files d'attente contribue à prendre des décisions administratives efficaces liées à la réduction du temps d'attente dans l'agence bancaire étudiée.

Mots-clés : Théorie des files d'attente, décision administrative, Banque CNEP – Agence de Jijel, QM Windows.

Classification Jel : C44, C60, M100.

INTRODUCTION

Fast advancements in all fields have resulted in a significant increase in risk and uncertainty, making traditional methods used in making administrative decisions ineffective, the reliance on modern quantitative methods as a means to handle various problems scientifically and precisely has become a necessity.

The theory of Queueing is among the most important operational research techniques used in solving problems related to reducing service wait time.

Here emerges the research idea that aims to examine the impact of queuing theory application on improving administrative decision making, using CNEP Bank agency of JIJEL as a case study.

RESEARCH PROBLEM

Due to the great economic importance of Banks, they are considered as one of the places with a large flow of customers from different ages, who wait for their turn to receive Banking services.

While the researcher was at one of CNEP Bank agency of JIJEL - ALGERIA, he was drawn to the presence of many customers waiting for their turn to receive service, which prompted him to conduct this research and understand the impact of applying queueing theory in reducing the waiting time and making sound administrative decisions.

The problem being researched can be summarized in the following questions:

- Does a Poisson distribution provide a good fit for the arrival rate data at CNEP Bank?
- Does the service time rate at the CNEP Bank adhere to an exponential distribution?
- Is there a role for using the queuing theory in making administrative decisions in a CNEP Bank (agency of JIJEL)?

OBJECTIVES OF RESEARCH

- Forecasting the distribution of the arrival rate for customers in CNEP Bank.
- Forecasting the distribution of the service time for customers in CNEP Bank.
- Determining the impact of applying Queuing Theory in administrative decision-making in CNEP Bank.

RESEARCH VARIABLES

- Independent variable: Application of Queuing Theory.
- Dependent variable: Administrative decision-making.

RESEARCH HYPOTHESES

- **The first hypothesis**: The rate at which customers arrive at CNEP Bank follows a Poisson distribution.
- **The second hypothesis**: The distribution of service times at CNEP Bank is exponential
- **The third hypothesis**: There is a moral role for using Queuing Theory in making administrative decisions in a CNEP Bank.

RESEARCH METHODOLOGY

To describe the study variables and find the relationship between them, the researcher relied on the descriptive analytical method, data and information were collected from books, articles … etc. On the applied side, information was collected from CNEP Bank

(JIJEL agency) through direct observations and conducting necessary analyses using the QM Windows program.

RESEARCH LIMITATIONS

- Spatial Boundaries: CNEP Bank (JIJEL agency ALGERIA).
- Temporal Boundaries: from January 20, 2023 to February 5, 2023.

RESEARCH THEORETICAL FRAMEWORK

1- Queuing theory

1.1- Concept of Queuing Theory

Queuing Theory is an operation research technique that models queues and calculates their performance and determines their characteristics to assist managers in making decisions (Abdel-Aal, 2020, p. 829).

The theory of queuing is a theory that deals with putting in place the necessary mathematical methods to solve problems related to situations that are characterized by congestions points or form queueing lines, as a result of the arrival of units seeking service and waiting for their turn, assuming that the arrival at the service location is random and the service time also takes a random form, thus making the service theory a probabilistic tool that allows for modeling the behavior of a service center (Doubosson & Rousseau, 1997, p. 328).

Queuing Theory, referred to as random service system theory, its research encompasses the following three elements (Lyua, Xiao, & Fan, 2021):

- The behavioral issue is to examine the probabilistic patterns of different queuing systems, primarily focusing on the distribution of queue length, waiting time, and busy periods, including both transient and steady states;

- The optimization problem is separated into static and dynamic optimization, the former involves designing the best solution, while the latter encompasses the optimal operation of the queuing system;

- The statistical inference of the queuing system involves determining which type of queuing system fits the models used for analysis and research within the framework of Queuing Theory.

1.2- Basic Elements of a Queuing Theory

- **Arrival Distribution**: Service seekers may arrive randomly or at a constant rate, and they may arrive individually or in groups (Santos & al, 2022, p. 210).

- **Service Discipline:** It refers to the method by which the service is provided, the service may be provided in a fixed or random manner, and the service rate is expressed in two ways: it may be in the form of the number of units that are served per unit of time, or it may be in the form of the time required to provide the service to the customer (Kochel, 2004, p. 157). and one of the most important forms of service discipline is:

  - (FCFS): "first come - first served", Is a principle in service management that handles queuing requests in a chronological manner (Wang & Liao, 2021, p. 25).

- (LCFS): "last come – first served", In the design of a tree-structured splitting algorithm for a multi-access communication system, the LCFS discipline is favored (Jouini, 2012, p. 3041).

As we also find (Gumus & al, 2017, p. 446):

- (SIRO): "service in random order".

- (PD): "priority discipline": Customers will be categorized based on their priority level.

- **System Capacity:** The customer count in a system can range from a minimum of 1 to an unlimited amount, including those waiting in line (Gumus, & al 2017, p. 446).

1.3- Fields of Application for Queuing Theory

The Queuing Theory has many applications in different fields, some of the most important include (Shanmugasundaram & Umarani, 2015, pp. 535-536):

- **Hospitals:** Queuing models are used to predict the waiting time of patients, measure the utilization of services, design system models, and assess appointment systems.

- **Traffic system**: Queuing theory can be utilized to minimize vehicular traffic flow and minimize delays on roads, A basic model of vehicular traffic based on queuing theory determines the optimal times for red, amber, and green lights to be turned on or off in order to reduce traffic congestion, This results in reduced fuel consumption and cost savings for the government, which can then be directed towards addressing other economic sectors.

- **Banking:** Most banks use standardized queuing models to make waiting times more efficient and to minimize the frustration of customers standing in long lines. Banks are an example of an unlimited queue, as the number of customers arriving and seeking different services (such as opening an account, making transactions, or checking their balance) is unpredictable and random. The queuing model helps the bank determine the order of customer arrival and the allocation of different services, each with its own unique processing time.

There are many other areas in which the queuing theory can be applied as it is an accurate scientific method that enables access to making sound administrative decisions (Health services, educational services, commercial spaces, libraries...etc.).

2- Administrative Decision Making

2.1- Concept of Decision Making Process

The process of decision-making, briefly defined as selecting the best option from the available alternatives within given more limitations and other conditions, is more complex than just a quick choice (TaGabat, 2019, p. 1).

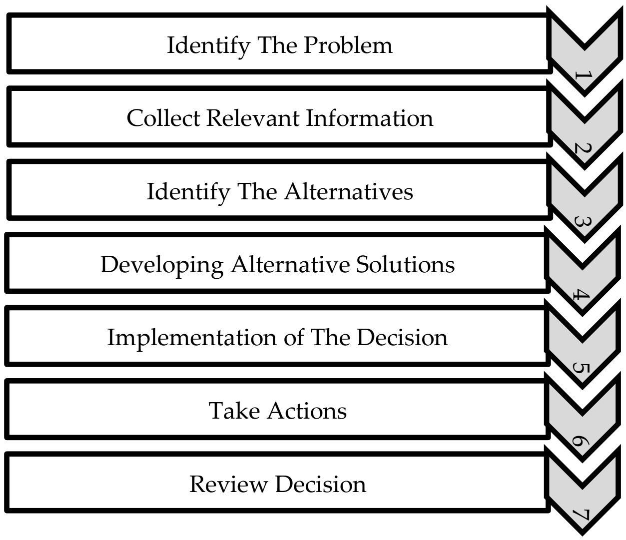
The decision-making process involves selecting the best option from multiple alternatives in order to attain a desired outcome (Lunenburg, 2010, p. 2).

2.2- Stages of Decision Making Process

There is a great difference by researchers in explaining the stages of the administrative decision-making process in the organization, but it is certain that its stages are sequential, and each time it is a complement to the second stage, and its aim is to reach a sound decision-making.

In general, the process of decision making in an organization can be presented in the following form:

Figure N° 1. Stages of decision making in an organization



***Source**: Panpatte, S., & Takale, V. (2019). To Study the Decision Making Process in an Organization for its Effectiveness. The International Journal of Business Management and Technology, 3(1), 73-78.*

3- The relationship between Queuing Theory and Administrative Decision Making

Queuing theory and administrative decision-making are interrelated fields in the sense that queuing theory provides a mathematical framework for understanding and analyzing waiting lines, and administrative decision-making deals with the process of making decisions within an organization. In a practical sense, queuing theory can be used by administrators to make informed decisions about resource allocation and service level optimization in order to improve the efficiency and effectiveness of operations. For example, queuing theory can be used to analyze the wait time of customers in a service system, to determine the optimal number of servers needed to minimize wait times, or to make decisions about how to allocate resources in a way that balances efficiency and customer satisfaction. by incorporating queuing theory into the decision making process, administrators can make data-driven decisions that result in improved operational performance.

4- Results and Discussion

4.1- Statistical Study of Customer Arrival Phenomenon

This study was applied at CNEP Bank (JIJEL agency in Algeria), the objective was to improve performance through the application of queueing models, and CNEP Bank was selected as a crucial one due to the formation of long waiting lines for customers.

- Statistical study of customer arrival phenomenon: The arrival of customers at this bank is done randomly and at uneven time intervals. To determine the probable distribution that the arrival rate is subjected to, we selected a sample consisting of 100 time periods taken randomly from the total number of observation periods, as shown in the table:

Table N° 1. Distribution of customer access to the Bank during the observation period

n° of arriving customers (x)	0	1	2	3	4	5	6	7	8	9	10	11	∑
occurrences (F0)	4	8	12	10	21	15	11	8	6	3	2	1	100

∑	0	8	27	32	81	79	59	62	47	8	9	17	429
(Each period equals 10 minutes)													

Source: According to the author

Arrival rate (λ): $\lambda = 429/100 = 4{,}29$

$\lambda = 4{,}29/10 = 0{,}429$

Test of K^2

- *H0*: Customer arrival distribution is not subject to Poisson Distribution.
- *H1*: Customer arrival distribution is subject to Poisson Distribution.

Poisson Distribution: $F_e = \frac{\lambda^{x} * e^{-\lambda}}{X!}$

Theoretical unlimited repetitions: $_e = \frac{x * e^{-\lambda}}{X!}$ x 100

The results obtained are summarized in the following table:

Table N° 2. Total cumulative difference (K^2) of customer access to the Bank

x_i	**Fe**	**F0**	**(F0 - Fe)²**	K^2
0	1.36048	4	2.96706	1.83766
1	5.77940	8	4.93106	1.55628
2	11.51034	12	0.23976	0.01186
3	7.03222	10	8.80771	3.74366
4	18.33168	21	7.11993	0.03250
5	14.58507	15	0.17216	0.03135
6	10.96550	11	0.00119	0.29930
7	6.273898	8	2.97942	0.51066
8	4.800548	6	1.43868	1.12137
9	1.888785	3	1.23479	0.38666
10	0.897418	2	1.21568	0.66146
11	0.320994	1	0.46104	1.62648
∑	/	100	/	11.81924

Source: According to the author

To determine the extent to which the studied phenomenon conforms to the Poisson distribution, we compare the value of the theoretical K² and its calculated value, and for that, we first calculate the degree of freedom:

$V = 12 - 1 - 1 = 9$

Theoretical $K^2 = 17.406$

Calculate $K^2 = 11.81924$

So we observe: Theoretical K^2 > Calculate K^2

We accept the *H1*: Customer arrival distribution is subject to Poisson Distribution.

4.2- Statistical Study of Service Time

First: Dividing the sample into equal time categorie

(Sturges method): $K = 1+3.322 \log 10 \text{ n} = 7.64 \approx 8$

(Category length): $T = 0.791$

The results obtained are summarized in the following table

Table N° 3. Average service time calculations at the Bank.

Service time	*F0*	Category center *T*	*F0 * T*
1.201 – 0.41	29	0.8044	23.3276
1.992 – 1.201	26	1.5864	41.2464
2.783 – 1.992	17	2.3885	40.6045
3.574 – 2.783	14	3.1885	44.639
4.365 – 3.574	6	3.9005	23.403
5.156 – 4.365	5	4.8605	24.3025
5.947 – 5.156	1	5.5415	5.5415
6.738 – 5.947	2	6.3325	12.665

∑	100	/	215.72

Source: According to the author

From the above table, the average service time is: $a=\sum\frac{215.02}{100}$ = 2.1572

$\frac{1}{a} = \frac{1}{2.1502}\mu$ = 0.455

Second: Conducting a test K^2 on the customer service crisis distribution.

Test of K^2 { *H0*: The distribution of customer service time does no follow the exponential distribution.
H1: The distribution of service time for customers follows an exponential distribution.

The total squared differences of the service time are shown in this table:

Table N° 4. The sum of the squared differences of the service times

Category center *T*	***F0***	***Fe***	**(*F0* - *Fe*)²**	**∑ *K*²**
0.8044	29	31.9731	8.8393	0.1216
1.5864	26	22.1332	14.9521	0.3714
2.3885	17	15.3216	2.81702	0.4680
3.1885	14	10.603	11.5396	0.5401
3.9005	6	7.3422	1.80150	0.2455
4.8605	5	5.0826	1.1719	0.0068
5.5415	1	3.5184	6.34233	0.6553
6.3325	2	2.4356	0.18974	0.0777
∑	100	/	/	2.7105

Source: According to the author

So we observe: Theoretical K^2 > Calculate K^2

(12.682) > (2.7105)

We accept the *H1*: The distribution of service time for customers follows an exponential distribution.

The results were obtained through the study of statistical distributions:

- The distribution of customers follows a Poisson distribution.

- The service time distribution follows an exponential distribution.

- The priority of service in CNEP Bank is for the first arriving customer (FIFO).

- The number of arriving customers is uncertain and the Bank's capacity to deal with customers is also uncertain.

4.3- Testing the third hypothesis:

4.3.1- Measurement of service time indicators from the customer's perspective

In order to analyze customer expectations, a sample of 100 customers was surveyed regarding the acceptable waiting time, and in this study, direct interviews were used as the fastest method of obtaining information, leading to the following results:

Table N° 5. Customer acceptable waiting time

Acceptable waiting time	The number	Percentage
Service time only	29	0.29
From 1 to 5 minutes	48	0.48
From 5 to 10 minutes	23	0.23
∑	**100**	**1**

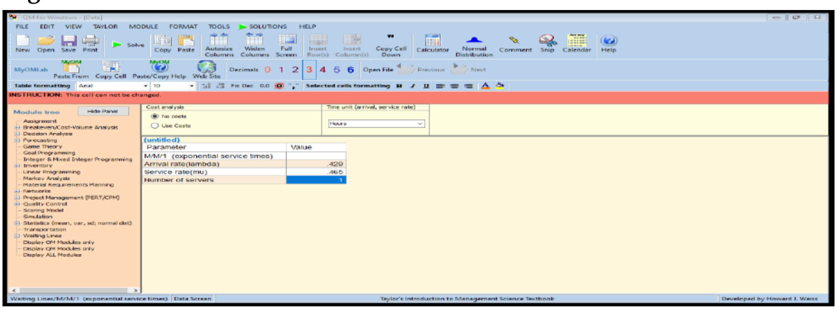
Source: According to the author

The above table indicates that there are some customers who never want to wait (most of them are elderly), and there is another category that accepts a wait of up to 20 minutes at the most.

4.3.2- Determining performance metrics for the service center

After determining both the arrival rate and service rate, it is possible to calculate the other metrics related to waiting models using QM Windows program, we choose from the program (QM Windows) M/M/1 then enter values for both the arrival rate (λ = 0.429) and service rate (μ = 0.465), and (S = 1) the following form is displayed for us:

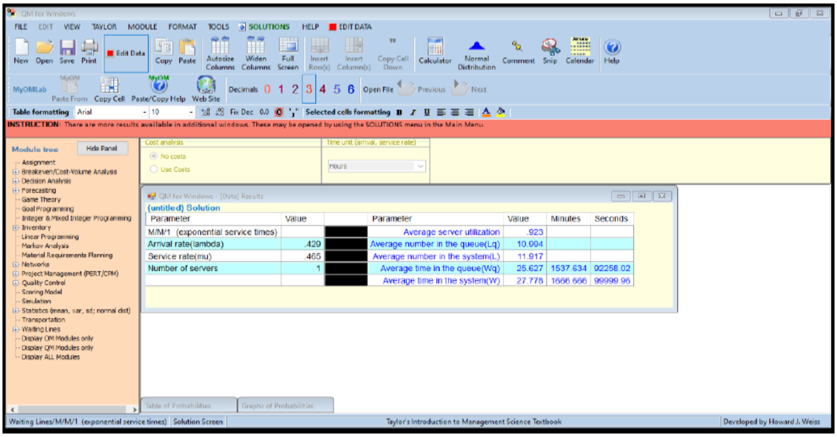
Figure N° 2. Access and service rates and the number of service centers



Source: According to the author, based on program (QM Windows)

After entering both the Arrival Rate and the Service Rate, we will get various performance indicators as follows:

Figure N° 3. model performance indicators



Source: According to the author, based on program (QM Windows)

Through the results of the above table, we notice:

- Utilization Rate: (P = 0.933).

- Average number of units in the waiting line: (Lq = 10.885 unit).

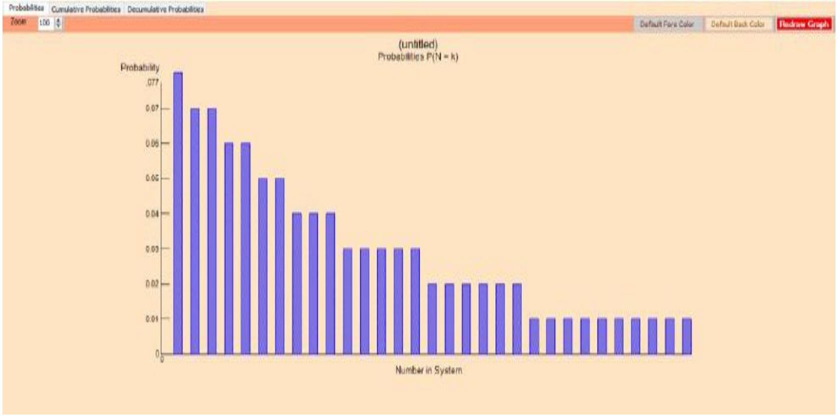
- Average number of units in the system: (Wq = 10.818 unit).

- Average waiting time in the queue: (Wq = 26.555 min).

- Average waiting time in the system: (Ws = 28.788 min).

After extracting performance indicators, it is possible to extract probabilities of the number of units in the system as:

Figure N° 4. Probabilities of the number of units in the system *N=K*



Source: According to the author, based on program (QM Windows)

By observing the figure, we notice that as the number of service centers increases, the number of units in the system decreases, which means the number of customers waiting to receive the bank service decreases.

4.3.3- The comment on the results of the performance indicators

- The utilization rate is 0.933, which means that there is a 0.92 probability that the system will be busy, meaning that 92% of the time the service providers will be occupied. This indicates congestion at the bank. The results also show that the service providers will be idle for 8% of the time.

- The average number of customers in the queue is 10.885, which is a very high number.

- The average number of customers in the system is 10.818.

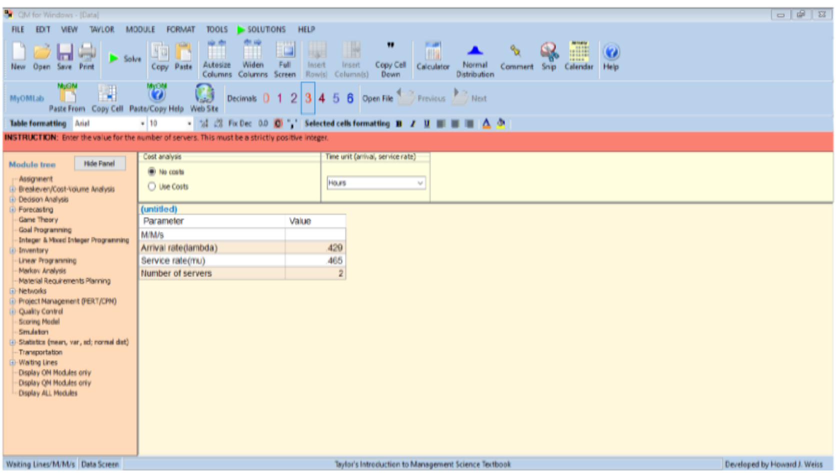
- The average wait time in the queue is 28.788 minutes, which is considered a long waiting duration.

- Through the performance indicators results *Ws*, *Wq* and comparing with the benchmark results, we find that the waiting time is very long, whether in the queue or in the system.

4.4- The proposed model as an alternative to the queue wait model in CNEP Bank:

From the program (QM Windows), after selection) M/M/S), we enter the Average Arrival Rate, Service Rate, and the Number of Service Centers equal to (2) and it results in:

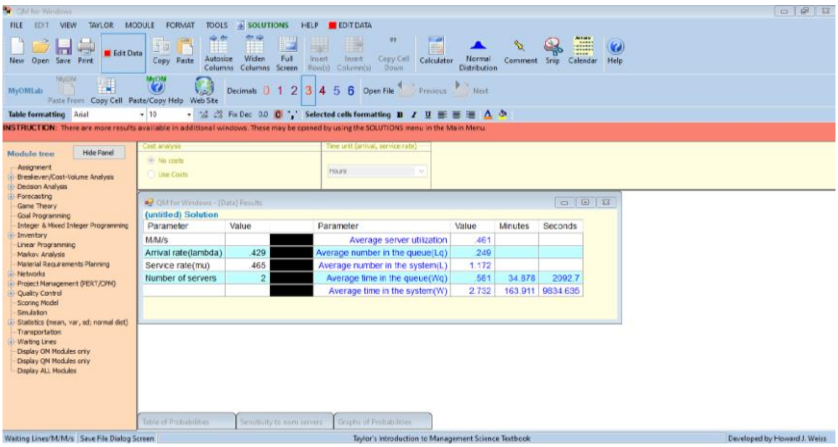
Figure N° 5. Access and service rates for the alternative model



Source: According to the author, based on program (QM Windows)

And then performance metrics are extracted:

Figure N° 6. Extract performance measures for the alternative model



Source: According to the author, based on program (QM Windows)

Through the results of the above table, we notice:

- Utilization Rate : (P = 0.461).

- Average number of units in the waiting line: (Lq = 0.459 unit).

- Average number of units in the system: (Wq = 1.111 unit).

- Average waiting time in the queue: (Wq = 0.574 min).

- Average waiting time in the system: (Ws = 2.632 min).

We observe that the utilization factor in the alternative model decreases to 45 %, and the average number of customers in the waiting line is 1.111 (one customer), while the average waiting time in the alternative model is 0.574 compared to 28.788 minutes in the current model.

Based on the results of applying the queue theory in the bank and after adding a new service center, we find that the proposed alternative model reduces waiting time, thus contributing to the taking of optimal administrative decisions to solve the waiting problem. Therefore, **we accept the third hypothesis**: there is a moral role for using queue theory in making administrative decisions in the CNEP Bank.

5- Conclusions and Recommendations

The results obtained in this study primarily consist of:

- The Distribution of Customers in The CNEP Bank Is subject to a Poisson Distribution, at a 5 % significance level and with parameter λ = 0.429. A Poisson distribution is a statistical probability distribution that expresses the probability of a given number of events occurring in a fixed interval of time or space if these events occur with a known constant mean rate and independently of the time since the last event.

- The service time distribution in the CNEP Bank is subject to an exponential distribution, at a 5 % significance level and with parameter μ = 0.456. This means that the probability of a customer being served in a given time interval is exponentially distributed, with a mean service time of $1/\mu$ = 2.19 minutes. The 5% significance level indicates that there is a 5% chance that the actual service time will be outside of the range of values predicted by the exponential distribution.

- There is an important role for the use of queuing theory in managerial decision making at CNEP Bank. Because it reduces the time to provide the service, as well as reducing waiting queues, which is reflected in the bank's reputation and customer dissatisfaction, in addition to the other benefits it provides related to reducing costs.

- This study has confirmed that the problem of waiting can be addressed by applying the theory of queue management in the CNEP Bank, the study site, by increasing the number of service centers.

- The proposed model has contributed to highlighting the role of queue management models in administrative decision-making and solving the problem of waiting using scientifically accurate methods.

- Most CNEP Bank employees have no idea about the theory of queue management.

As the following suggestions and recommendations can be presented:

- It is important for decision makers in the CNEP Bank to pay attention to quantitative methods for solving waiting problems, including the theory of queue management in particular, as it is effective.

- The necessity of training CNEP Bank employees on the use of quantitative methods to solve problems.

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