Measuring performance indicators of entry gates for external transport trucks to container terminals in Iraqi ports by using queuing theory

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Abstract

At the present time and as a result of the rapid development and fierce competition between business organizations including ports, these organizations must reach the highest levels of specialization in their field of business in order to increase their competitiveness. As the management of logistical activities plays an essential role in the work of ports by controlling all activities related to service provision in each part or work system inside and outside the port. The research aims to improve the activity of entry of external transport trucks to the port, through the use of queuing theory models to measure the performance indicators of the entry gate of external transport trucks to container terminals. For the purpose of reducing waiting time for trucks transportation, balancing waiting costs and service costs, in addition to working to reduce the total cost. The results of the research concluded that the use of queuing theory models contributed to improving the management of the activity of transport trucks entering the port and recommendations will be presented at the end of the research.

Keywords: Measuring performance indicators, external transport, container terminal, Queuing theory.

1.Introduction

The rapid development of the international shipping market, the changing sizes of ships and transport companies, are all factors that represent new challenges to the management of ports. In order to develop and advance the status of these ports, managements are required to provide infrastructure and the gradual application of flexible technology that are capable of facing challenges in the maritime transport sector (Ya-nan and Guo-Qing,2021:797). Ports are viewed as multi-modal gateways, and crucial links in the international trade network. They represent the links (nodes) that connect land and water to good transport, and determine the locations and distributions of global supply chains (Notteboom and Rodrigue,2009:3; Becker et al.,2013:683; Ng et al.,2015:2). The logistics industry is described as a competitive environment, linked to the phenomenon of globalization, which requires organizations to have more flexibility, greater performance and a constant search for cost reduction (Jeganathan and Naveenkumar ,2019:433).

The high operating costs and poor customer service that most organizations face are actually due to multiple factors. The most important factor is the weakness of logistics management. This is because the modern business world coupled with massive competition which requires organizations to pay high attention to managing logistics services as it represents one of the main emerging determinants of the organization's profitability and growth (Vedaste and Muiruri,2021:39). The management of logistics services reduces the total operating costs of business

organizations, and increases the efficiency of the business activities of the organization (Abdul et al.,2019:37). This is what prompted the management of those organizations to find the complementary interdependence between the concept of logistics management with planning, organization, and control, because of their fundamental implications in the movement of human, material, financial, and informational flows (Topolšek et al.2018:1196). Therefore, the key to success in logistics management requires a high focus on cooperation, coordination, information exchange, and integration of activities in all parts of the supply chain, starting with suppliers and ending with customers, in order to be able to respond quickly to integration challenges. It has a fundamental role to play in the business environment in conjunction with current developments in information and communication technologies (Lourenco,2005:330). The use of queuing theory enables managers to make better decisions in an attempt to reduce waiting time through optimal planning of equipment utilization, which will positively affect productivity, service, and waiting time (Shojaie et al.,2012:2110). Therefore, the use of queuing theory models is an attempt to reach the best decisions related to logistics management (Motlagh et al.,2019:3).

Accordingly, the research aims to evaluate the performance of a work system for one of the logistical activities related to providing service to external transport trucks (entry gate for external transport trucks) in the port of Umm Qasr. This can be done through measuring performance indicators (the expected number of trucks waiting to receive service and the expected waiting time for trucks) using one of the research

methods operations (queuing theory) for the purpose of improving the performance of the service system for external transport trucks. At the same time, reducing costs for the entry activity of external transport trucks through the entry gate of container terminals in the port of Umm Qasr to the extent that achieves a balance between the costs of providing service and waiting costs through the application of models queue theory.

2.Literature review

This section aims to review the literature to provide a clear view of the importance of logistics management and the applications of queuing theory in the field of managing logistics activities. Given that the research objective is to measure performance indicators for the activity of entry of external transport trucks to container terminals, which is an important activity of logistics activities in the port.

2-1. Logistics Management

Logistics management is related to transportation and movement from one point to another in the supply chain, warehousing, production, handling, and storage of goods in a convenient location. These activities include controlling the movement of goods and complex administrative procedures such as processing and delivery orders (Assawasoontorn, 2002; Ristovska et al. 2017). Logistics management includes planning, controlling, and monitoring the forward and reverse flow of materials, energy, and information within an organization and between other organizations (Kain and Verma, 2018). Also, logistics management is a field of knowledge that has developed dynamically over time and depends on the effectiveness of logistics activities and other

areas of human activity (Korpysa et al., 2021). As successful logistics management leads to cost reductions, improved product quality (goods and/or services), and the continuity and growth of organizations. business, and achieving added value (Assawasoontorn,2002:5 ;Tudor,2012:24).

Logistics management for organizations ensures that products are delivered to customers in the right place, at the right time, and at the right cost (Kangavalli and Azeez, 2019:12804 ; Ballou, 2007:376). Because it is an integrative function that works on the process of integrating various logistics activities with functions (marketing, financing, sales manufacturing, information technology). In addition, integrating the movement of goods, services, and capital from their sources to the consumer, and managing internal and external transport (Ghoumrassi and Tigu,2018:408).

2-2. Queuing Theory

The queuing theory is defined as a mathematical method used to analyze multiple types of systems and monitor their behavior, which is related to evaluating system performance and quality (Mehandiratta,2011:7). The theory uses a set of techniques to analyze systems that often have competition for resources and therefore provides special tools. To analyze the critical factors for expected long queues in organizations that provide services, through (queue, expected waiting time for each queue) (Bahaweres et al.,2017:2), so it represents the most used tool for solving problems with waiting systems, and through it Reaching the optimal solutions in the form of performance measures (Kalwar et al.,2021:7). The queuing theory is also a branch of operations research, which explores the relationship between the demand for a particular service

system and the delays experienced by the users of that system (Sagayaraj and Amudha,2018:386). As the results drawn from the use of queuing models are often used when making business decisions about the type and quantity of resources needed to provide the service, and it also works on analyzing probabilistic systems for clients and servers. and there are more important applications of the theory. a large number of which have been documented in the literature on probability, operations research, and management science (Sharma and Sharma,2013:1). And among the most important of those applications that have been made on intelligent transport systems, communications, traffic flows (Komashie et al.,2015:2), networks and computing, project management, operating systems scheduling, and transportation and logistics (Ammar,2017:337).

The application of the queuing theory could lead in various sectors - including ports - to a reduction in total costs, as it works to reduce wasted time in waiting lines for different means of transport, and work to balance the costs of adding new service centers (Valeriano et al.,2021:2521). This is done through rapid modeling of different systems, even if the environment is subject to a certain degree of complexity and uncertainty, where the state of uncertainty is managed in a manner commensurate with the situation or situation, through the statistical distributions of input data such as (access rates, service rate) of the model The waiting used, and thus the application of these models of the theory will enable access to the lowest total cost, resulting from wasted time in long waiting periods and obtaining the service and the additional

costs of workers to provide the service (Hartiati and Mulyani,2015:256).

3.Research problem

The main problem of the research is the overcrowding experienced by external transport trucks while passing through the entry gates of container terminals.

4.Research questions

The current research is based on the following questions:

How? And how far? The performance of the service channels for the entry gates for the entry of external transport trucks to the container terminals at Umm Qasr port can be improved.

5. Research aims

The aim of the research is to work on improving the process of passing external transport trucks from the entry gate to the container terminals at Umm Qasr Port, by estimating the performance indicators of those gates using the queuing theory models.

6.Field of application:

Due to the importance of the port sector in Iraq, specifically in the port of Umm Qasr, this research was conducted on two container terminals in the port of Umm Qasr, namely: first - the Basra multipurpose container terminal (BMT) and secondly - the Basra Gate container Terminal (BGT). And work on measuring performance indicators for the service channels in those stations represented by (individuals working on checking entry permits) at the entry gate. For each of the stations specified in the research, as the study data was collected through field visits, Due to the lack of required data (arrival times and service times for transport trucks) at the port administrations and the difficulty of collecting a large number

of such data, 50 truck data were collected for each activity in order to be able to estimate performance indicators, and queuing theory models were applied to determine performance indicators. This is done by using a set of mathematical equations and models as follows

7.General equations used in calculating performance indicators

- There is a set of mathematical formulas that explain the relationship between the performance indicators of the queue models, shown by equations (1), (2), (3), (4) (Sharma 2016:568) as follows:

$$w_s = W_q + \frac{1}{\mu} \quad \dots(1)$$

$$L_s = L_q + \lambda \quad \dots(2)$$

$$W_q = \frac{L_q}{\lambda} \quad \dots(3)$$

$$W_s = \frac{L_s}{\lambda} \quad \dots(4)$$

- [illegible] following equation (Kabamba ,2019:6) :

$$Tc = Cw\ Ls + Cs\ K \quad \dots(5)$$

whereas:

Cw : the cost of waiting per time period per customer
Ls: The average number of clients in the system
Cs: The cost of service per time period for each channel
K: The number of service channels

8.Queue models used in the study

In the current research, two mathematical models were used for the queuing theory, because each of the inter-arrival times and service times are distributed exponentially, which is compatible with these two models only. As for the

characteristics of the two models they are as follows

8-1.The first model: the M/M/1 Queue model

This model (M / M / 1) is characterized by following the (Poisson) distribution for access at a rate (λ) per time period and service rate (μ) with an exponential distribution (that is, the interfaces follow the exponential distribution), one service channel, infinite system capacity, and system Queue (FCFS), which is one of the simplest models of queues, and performance indicators are calculated according to the following equations (Sharma,2016:571,574-575) :

$$L_s = \frac{\rho}{1-\rho} = \frac{\lambda}{\mu-\lambda};\ \rho = \frac{\lambda}{\mu}\ ;\ \lambda < \mu \quad \dots(6)$$

$$L_q = \frac{\lambda}{\lambda-\mu} - \frac{\lambda}{\mu} = \frac{\lambda^2}{\mu(\mu-\lambda)} \quad \dots(7)$$

$$W_q = \frac{\lambda}{\mu(\mu-\lambda)}\ or \frac{L_q}{\lambda} \quad \dots(8)$$

$$W_s = W_q + \frac{1}{\mu} = \frac{1}{\mu-\lambda}\ or\ \frac{L_s}{\lambda} \quad \dots(9)$$

$$P_0 = 1 - \frac{\lambda}{\mu} = 1 - \rho \quad \dots(10)$$

$$P_n = (1-\rho)\rho^n \quad \dots(11)$$

identical service channels, which leads to an increase in the service rate of the system as a whole. And the queue model (M / M / c) is characterized that the access process follows a (Poisson) distribution, and an arrival rate (λ), and the distribution of service times is exponential at a service rate (μ), and the presence of a number of service channels. And performance indicators for this model are calculated according to The following equations (Taha ,2020:675-676) :

$$P_n = \begin{cases} \frac{\rho^n}{n!} P_0\ ; n < c \\ \frac{\rho^n}{c!\, c^{n-c}} P_0\ ; n \geq c \end{cases} \quad \dots(12)$$

$$P_0 = \left\{ \sum_{n=0}^{c-1} \frac{\rho^n}{n!} + \frac{\rho^c}{c!}\left(\frac{1}{1-\frac{\rho}{c}}\right) \right\}^{-1}\ ;\ \frac{\rho}{c} < 1 \quad \dots(13)$$

$$L_q = \frac{\rho^{c+1}}{(c-1)!\,(c-\rho)^2} P_0 \quad \dots(14)$$

$$L_s = L_q + \rho \quad \dots(15)$$

$$W_q = \frac{L_q}{\lambda} \quad \dots(16)$$

$$W_s = \frac{L_s}{\lambda} \quad \dots(17)$$

whereas:

$$\lambda_n = \lambda\ ; n \geq 0$$

$$\mu_n = \begin{cases} n\mu\ ; n < c \\ c\mu\ ; n \geq c \end{cases}$$

c: number of service channels

9. Practical Framework

The Matlab programing language was used to formulate the performance indicators estimation program for the mathematical models of the queuing theory specified in the research, and after implementation we got the following:

9-1. The entry gate for external transport trucks to the Basra Multipurpose Container Terminal (BMT).

9-1-1. Estimation Performance indicators:

Table (1) shows the data of the inter-arrival times of the external transport trucks to the gate of the (BMT) station, which works to transport containers from the container yard at the (BMT) station to the destination of the container (outside the port). The service times of the service channels represented by the audit employee at the entry gate .

Table (1) Data of inter-arrival times and service times for entry of external transport trucks to the gate of the (BMT) station, measured in minutes

inter-arrival times	**1.13 1.15 1.10 1.10 1.25 1.15 1.25 1.17 1.15 1.16 1.18 1.09 1.12 1.16 1.14 1.07 1.21 1.18 1.05 1.18 1.16 1.18 1.06 1.11 1.17 1.15 1.15 1.19 1.12 1.15 1.18 1.20 1.13 1.11 1.15 1.10 1.04 1.15 1.20 1.58 1.20 1.10 1.15 1.14 1.05 1.15 1.15 1.13 1.18**
service times	**1.05 1.07 1.05 1.00 0.55 1.02 0.54 1.00 1.08 1.05 1.09 1.03 1.07 1.14 1.15 1.08 1.12 1.02 1.01 1.06 1.15 1.10 1.03 1.08 1.03 1.06 1.05 1.12 1.04 0.58**

	1.09 1.02 1.05 1.09 1.15 1.18 1.04 1.06 1.10 0.58 1.03 1.11 1.07 1.10 1.18 0.59 1.01 1.10 1.07

Source: Prepared by researchers based on field visits

As for estimating the performance indicators of the service channel at the BMT entry gate, they are summarized in the following points:

- The data of inter-arrival times and service times follow an exponential distribution, as their statistics are summarized in Figure (1), and thus we find that the appropriate queue system is (M/M/1).

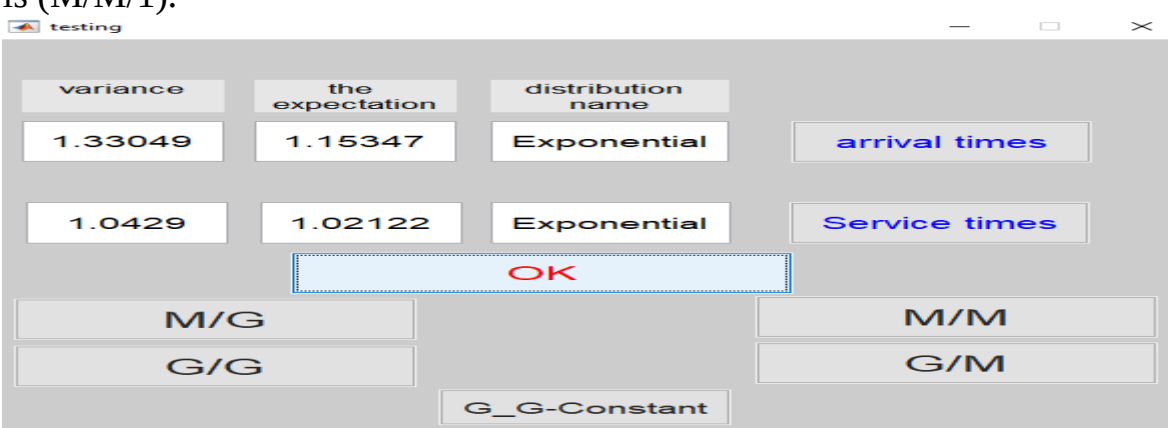

Figure (1) Testing window (Source: Prepared by the researchers based on the outputs of the MATLAB program)

- According to the queue system (M / M / 1) and after entering the number of service channels (entry permit auditing employee) (1) and entering each of the waiting cost is (350 dinars/minute). The service cost is (600 dinars/minute), which is provided by the port management of Umm Qasr, the performance indicators for this system shown in Figure (2) and summarized in Table (2) have been estimated.

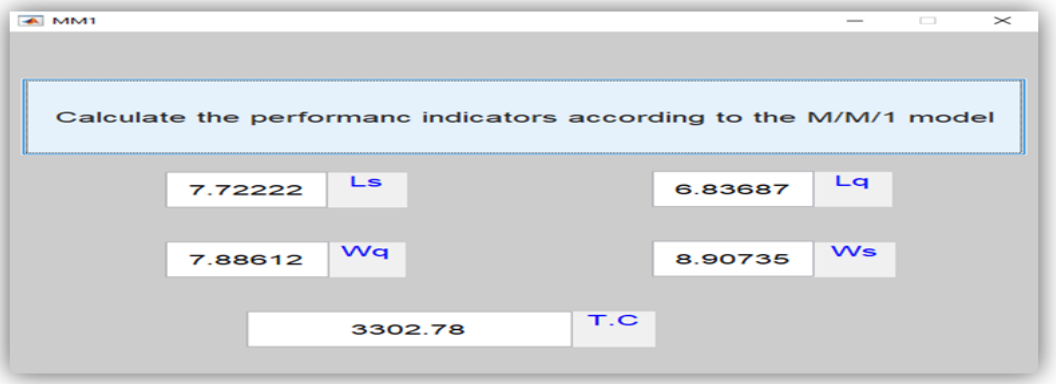

Figure (2) The performance indicators calculation window for the container terminal (BMT) entry gate (Source: Prepared by the researchers based on the outputs of the MATLAB program)

9-1-2.Commenting on the results of the performance indicators and their interpretation:

Through the results presented in Figure (2), which represent the performance indicators of the container terminal (BMT) entry gate, it is noted that:

- The average number of trucks in the queue waiting for the specified gate (Lq) is approximately 7 trucks, and it is noted that it is a large number and is not commensurate with the costs of waiting for external transport trucks.
- The average number of external transport trucks in the system (Ls) is equal to 7.7 trucks, which is approximately 8 trucks.
- The average time spent for trucks in line (Wq) is 7.8 minutes and close to 8 minutes, which is a long time to wait for outbound trucks.
- The average time spent for trucks in the system (Ws) is 8.9

minutes, meaning that the waiting period for trucks in the queue system is approximately 9 minutes.

According to the results of the two performance indicators (Wq, Ws), and after presenting them to those in charge of managing the logistics activities in the port, it was found that each of the waiting time spent by external transport trucks in the waiting queue or in the system is unacceptable, so the current work system requires. An improvement was made to the process of entering trucks through the entry gate of the Container Terminal (BMT).

9-1-3.The proposed model as an alternative to the queuing system at the entry gate of a container terminal (BMT) :

The researchers suggest that those in charge of the logistics department make an improvement on the process of passing trucks through the entry gate of the specified station. In order to reduce the waiting time for transport trucks, by adding a new service channel (auditing employee), so that the number is (two instead of one). At the entrance gate of the station, and by applying the (M/M/c) model to the proposed number, the results of the performance indicators are as shown in Figure (3).

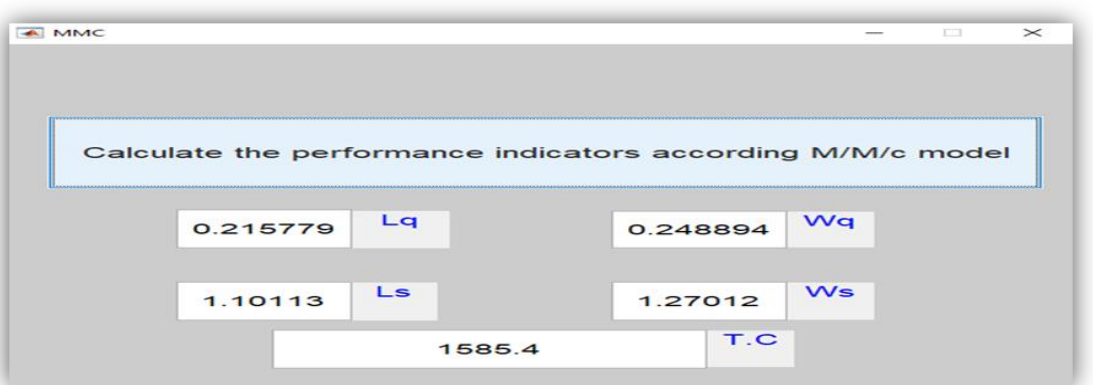

Figure (3) Performance indicators window after adding a second service channel (Source: Prepared by the researchers based on the outputs of the MATLAB program)

From the results presented in Figure (3), it is noted that:

- The decrease in the average number of trucks in the waiting queue (Lq) from approximately 7 trucks to approximately 1 truck, meaning that the percentage of reducing the number of trucks in the waiting queue is approximately 85%, with a reduced number of trucks amounting to approximately 6 trucks, which is a suitable number for the nature of the work of trucks.
- The decrease in the average number of trucks in the system (Ls) from 8 trucks to 1 truck, and it represents the number of trucks in the waiting queue in addition to the number of trucks for which the service is provided. Meaning that the amount of reduction in the number of trucks in the system is 7 trucks, at a rate of approximately 87%.
- The decrease in the average time spent by trucks in waiting queue (Wq) from 7.8 to 0.2 minutes, meaning that the amount of reduction in time spent by trucks in waiting queue is 7.6 minutes, by approximately 97%.
- The decrease in the average truck time spent in the system (Ws) from 8.9 to approximately 1.3 minutes, thus the amount of time reduced after adding a second gate is 7.6 minutes, by approximately 96%.
- The decrease in the total cost of the service by a large percentage estimated at approximately 52%, from (3302.78 dinars/minute) to (1585.4 dinars/minute). This indicator

indicates that the proposed queue model (adding an audit employee) achieves the highest profit and approaches the optimal level of service at the lowest cost possible.

According to the results of performance indicators, and after presenting them to those in charge of managing the logistics activities in the port, it was found that each of the waiting time spent by external transport trucks in the waiting queue or in the system after adding a service channel. It is considered acceptable and the proposed work system does not require further improvement in the truck entry process through the proposed number of service channels at the entry gate of the container terminal (BMT). Table (2) shows the amount of change in the performance indicators before and after adding the service channel.

Table (2) The amount of change in the performance indicators before and after adding the service channel in the entrance gate of the (BMT) station

queue model	number of service channels	Lq	Ls	Wq	Ws	Cs* K	Cw* Ls	T.C
current model	1	6.83687	7.7222	7.8861	8.9073	600	2702.78	3302.78
proposed alternative model	2	0.21577	1.1011	0.2488	1.2701	1200	385.4	1585.4

Source: Prepared by the researchers based on the results of the performance indicators

By comparing the performance indicators and the total cost of

the two models (current and proposed), shown in Table (2), we conclude that the best queue model is the proposed model (adding a service channel), because it works to reduce the number of trucks in the queue and the system, and reduces the time. The time spent in both the waiting queue and the system, which in turn leads to a reduction in the waiting cost by a greater percentage than the increase in the service cost resulting from adding a service channel (entrance gate). Therefore, it works to reduce the total cost, and gives preference to the proposed model over the current model.

9-2.The entrance gate for external transport trucks to the Basra Gate Container Terminal (BGT).

9-2-1. Estimation Performance indicators:

Table (3) shows the data of the inter-arrival times of the external transport trucks to the entry gate of the container terminal (BGT), and the service times of the service channels at the specified station gate, as follows:

Table (3) Data of inter-arrival times and service times for the arrival of external transport trucks to the container terminal (BGT) gate, measured in minutes

inter-arrival times	**1.22 1.25 1.29 1.34 1.28 1.27 1.31 1.25 1.30 1.25** **1.37 1.32 1.24 1.36 1.27 1.41 1.28 1.31 1.25 1.24** **1.39 1.23 1.28 1.29 1.33 1.26 1.27 1.32 1.30 1.29** **1.25 1.31 1.27 1.35 1.26 1.40 1.32 1.25 1.30 1.24** **1.38 1.35 1.44 1.26 1.28 1.31 1.29 1.35 1.23**
service times	**1.20 1.18 1.20 1.21 1.20 1.23 1.19 1.17 1.24 1.25** **1.20 1.19 1.18 1.22 1.19 1.17 1.25 1.15 1.24 1.15** **1.16 1.19 1.20 1.18 1.20 1.22 1.17 1.20 1.23 1.15** **1.19 1.25 1.21 1.14 1.22 1.15 1.25 1.16 1.10 1.15**

	1.18 1.21 1.19 1.17 1.22 1.25 1.18 1.17 1.14

Source: Prepared by researchers based on field visits

In order to estimate the performance indicators of the process of passing (entry) of external transport trucks through the entry gate of a container terminal (BGT), the same previous steps are followed in analyzing the inter-arrival times and service times to determine the imaginative distribution of them and then determine the appropriate queue model, as shown in Figure (4).

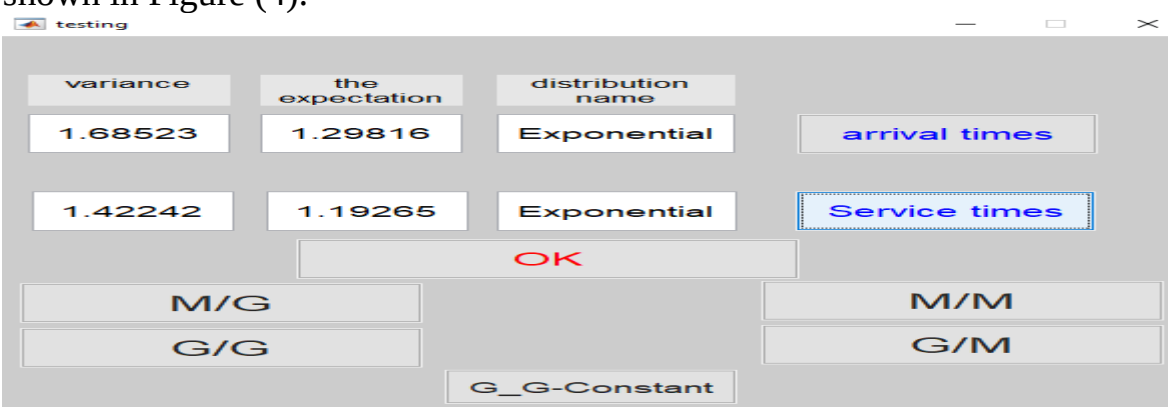

Figure (4) Testing window.

Source: Prepared by the researchers based on the outputs of the MATLAB program

According to the Figure (4), it is noted that each of the inter-arrival times and service times are distributed exponentially. Thus the appropriate model for estimating performance indicators is the (M/M/1) model. After that, the number of service channels represented by (the entry permit audit employee) was entered into the station portal containers and amount (one service channel), in addition to entering the waiting cost of (350 dinars/minute), and the service cost of (600 dinars/minute), the performance indicators for this system shown in Figure (5) have been estimated.

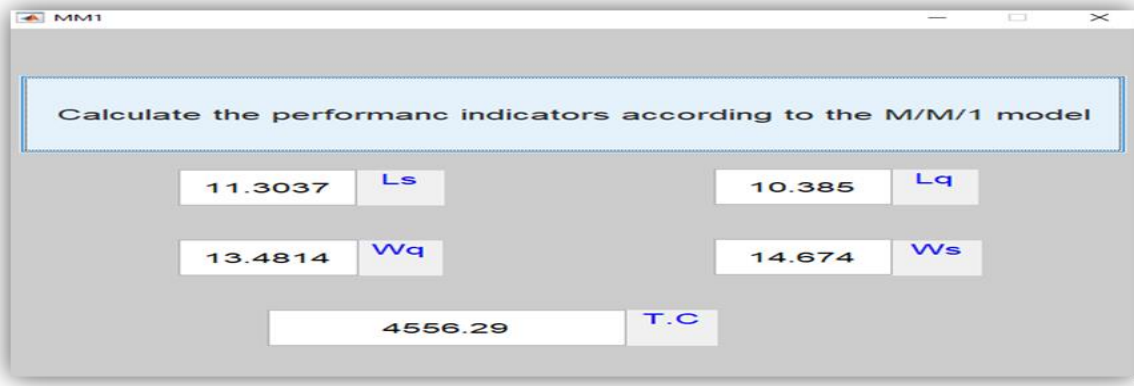

Figure (5) Performance Indicators Estimation Window
Source: Prepared by the researchers based on the outputs of the MATLAB program

9-2-2. Discussion the results of the performance indicators and their interpretation:

Building on the results presented in Figure (5) for calculating the performance indicators, the entry gate to the container terminal (BGT), we found that:

- The average number of internal transport trucks in the queue (Lq) is 10.3, meaning that there are approximately 10 trucks in the queue. It is noted that it is a large number and does not fit with the nature of the work and needs an improvement in the queuing system.
- The average number of internal transport trucks in the system (Ls) is approximately 11 trucks.
- The average time spent (Wq) for trucks in the waiting line is 13.4 minutes, which is a long period and needs to be reduced and commensurate with the nature of work.
-The average time spent (Ws) for trucks in the system is 14.6 minutes, which represents the time spent by trucks in the

waiting queue in addition to the time it takes to receive service and pass from the gate to the station, which is approximately 15 minutes.

-The total cost (T.C.) equals (4556.29 dinars/minute).

According to the results of the performance indicators and after presenting them to those in charge of managing the logistics activities in the port, we found that both the number and the waiting time that transport trucks spend in the waiting queue or in the system is unacceptable, and it needs to make improvements on the current situation of the queue system The work of the entry gate.

9-2-3.The proposed model as an alternative to the container terminal (BGT) gate queuing system:

The researchers suggest to those in charge of managing the logistics activities to make an improvement on the BGT entry gate queuing system, by adding a new service channel (audit employee), so that the number of channels is two channels, and by applying the model (M/M/c) on the number of proposed service channels, performance indicators estimates are presented after adding a service channel, as shown in Figure (6).

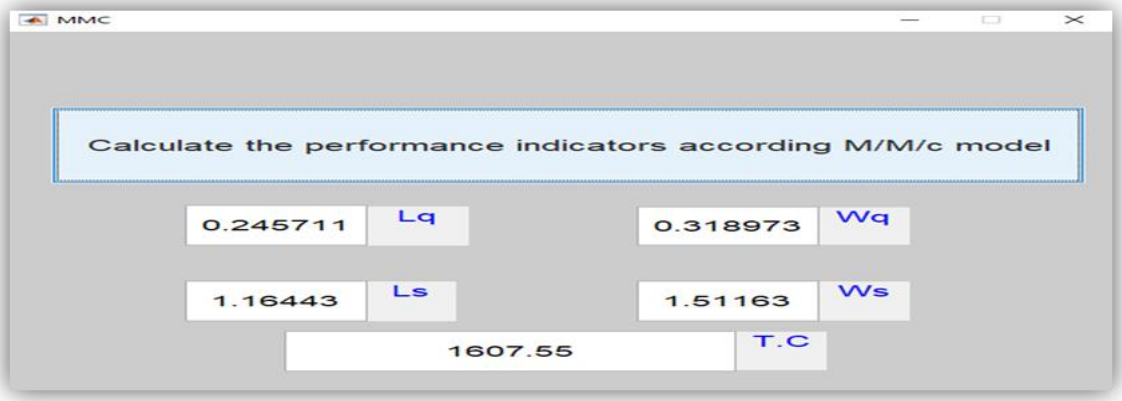

Figure (6) Calculation of performance indicators window after adding a service channel to the container terminal (BGT) entry gate

Source: Prepared by the researchers based on the outputs of the MATLAB program

9-2-4.Comparison between the current model and the proposed model:

The results of the performance indicators and the total cost estimated by the queuing models, for the current model and the proposed model as an alternative to the queuing system of the container Terminal Entry Gate (BGT) are summarized in Table (4).

Table (4) Estimated performance indicators for the container terminal (BGT) entry gate before and after adding the proposed service channel

queue model	number of service channe	Lq	Ls	Wq	Ws	Cs	Cw	T.C

	ls							
current model	**1**	**10.385**	**11.3037**	**13.4814**	**14.674**	**600**	**3955**	**4556.29**
proposed alternative model	**2**	**0.2457**	**1.1644**	**0.3189**	**1.5116**	**1200**	**406**	**1607.55**

Source: Prepared by the researchers based on the results of the performance indicators

In table (4), it is noted that the results of performance indicators for the process of passing external transport trucks through the entry gate of a container terminal (BGT), have changed as follows:

- The decrease in the average number of trucks in the waiting queue (Lq) from approximately 10 trucks to almost no truck in the waiting queue, and this indicator indicates that there is a reduction in the number of trucks in the waiting queue by 10 trucks. By almost 100% of the number of trucks in the queue wait before adding the proposed service channel to the entry portal.
- The decrease in the average number of trucks in the system (Ls) from 11 trucks to approximately 1 truck, meaning that the addition of a new service channel reduced the number of trucks in the system by 10 trucks, or by approximately 91% of the number before adding the proposed service channel.
- The decrease in the average time spent by a truck in waiting queue (Wq) from 13.4 minutes to 0.3 minutes, and the percentage of reduction reached about 97% of the time spent before adding the proposed service channel.

- The decrease in the average truck time spent in the system (Ws) from 14.6 minutes to 1.5 minutes, as the addition of the proposed service channel reduced the time spent for trucks in the system by approximately 89%.
- The decrease in the total cost from (4556.29 dinars / minute) to (1607.55 dinars / minute), and this indicator, which is considered one of the important indicators, indicates that the proposed model for improvement (adding a service channel), led to a reduction of more than half of the total cost, by a rate of more than from approximately 64%, which is a high percentage, and this reduction in the total cost is realized profits that are added to the profits of the port.

According to the results of the performance indicators, and after presenting them to those in charge of managing the logistics activities in the port, we find that each of the waiting time spent by transport trucks in the waiting queue or in the system after adding a new service channel at the entry gate of a container terminal (BGT), is acceptable. It does not need to make further improvements to the proposed model of the queuing system.

10.Results and Discussion

Tables (2 and 4) summarize the performance indicators for each of the models (current and proposed models) for the work system of each of the entry gates of external transport trucks for the two terminals (the Basra multi-purpose container terminal and the Basra Gate container terminal).

1-The results of the performance indicators of the process of passing external transport trucks through the entry gate to the Basrah Multipurpose container Terminal (BMT).

The performance indicators related to the activity of passing external transport trucks through the entry gate to the Basra Multipurpose Container Terminal (BMT), which are summarized in figure (2). And after presenting them to those in charge of managing the logistics activities in the port, indicated that the model proposed by the researchers, which includes increasing the number of channels (review employee Documents) by one service channel so that the total number (two service channels) is considered acceptable. This is better than the system currently in use (one service channel) because it reduces the total cost due to the low cost of waiting and works to increase the service rate and reduces the number of trucks and their waiting time in the queue and the system .

2-The results of the performance indicators of the process of passing external transport trucks through the entry gate to the Basra Gate Terminal (BGT) entry gate.

The results of the performance indicators for the process of passing external transport trucks through the entry gate to the Basra Gate Container Terminal (BGT), which are summarized in Figure (4). And after presenting them to those in charge of managing the logistics activities in the port, indicate that the model proposed by the researchers, which includes increasing the number of channels (review employee documents) by one service channel. So that the total number (two service channels) is considered acceptable and is better than the current system (one service channel) because it reduces the total cost due to the reduction of the waiting cost. This leads to improving the service rate and achieving additional profits from this activity and reduces the number of trucks and their waiting time in the queue and the system.

11.Conclusion

Building on the results, we conclude that the application of mathematical models (queuing theory models) has led to an improvement in the performance of the entry gates of the two stations by measuring the performance indicators of the service channels in those gates represented by the document review employee and suggesting an alternative work system for each of the entry gates to the stations. After presenting the results to those in charge of the logistics activities tool in the port, we conclude the following:

1- The system of work (the current queue system) for the process of passing external transport trucks through the entry gate to the Basra multi-purpose container terminal is not acceptable, and that the alternative system proposed in this research is better than the current system because it works to reduce the number and waiting time of external transport trucks in Queuing and ordering also leads to a reduction in the total cost.

2- The unacceptability of (the current queue system) for the process of passing external transport trucks through the entry gate to the Basra Gate Container Terminal, and that the alternative system proposed in this research is better than the current system. This is because it works to reduce the number of trucks in the waiting queue and the system also reduces the waiting time for those trucks in the queue and the system in addition to that it leads to a reduction in the total cost.

11.Limitations and future research

The researchers faced the difficulty of obtaining this type of data related to the application of the different models, and

they relied on field visits due to the lack of documented data from the port management. The models were applied to specific parts of the logistics activities. Therefore, we recommend applying the network queuing theory to evaluate a group of sequential activities in the port and expanding the field of application in addition to applying it in various sector.

References:

1. Abdul, F. A., Iortimbir, A. I., OLADIPO, G. T., & OLOTA, O. O. (2019). "Impact of logistics management on organizational performance (A case study of Dangote Flour Mills Plc, Nigeria)", Journal of Sustainable Development in Africa, 21(1),pp. 36-49.
2. Ammar, S. I. (2017). "Transient solution of an M/M/1 vacation queue with a waiting server and impatient customers", Journal of the Egyptian Mathematical Society, 25(3),pp. 337-342.
3. Assawasoontorn, N.(2020) "Logistics management for a trading company", A Final Report of the Six-Credit Course CE 6998 — CE 6999 Project.
4. Bahaweres, R. B., Fitriyah, A., & Rozy, N. F. (2017, August). "Comparative analysis of business process litigation using queue theory and simulation (case study: Religious courts of south jakarta)", In 2017 5th

International Conference on Cyber and IT Service Management (CITSM), pp. 1-7

5. Ballou, R. H. (2007). "The evolution and future of logistics and supply chain management", Production, 16,pp. 375-386.
6. Becker, A. H., Acciaro, M., Asariotis, R., Cabrera, E., Cretegny, L., Crist, P., ... & Velegrakis, A. F. (2013). "A note on climate change adaptation for seaports: a challenge for global ports, a challenge for global society", Climatic change, 120(4),pp. 683-695.
7. Ghoumrassi, A., & Tigu, G. (2018, May)."The impact of the logistics management in customer satisfaction", In Proceedings of the International Conference on Business Excellence ,Vol. 12, No. 1, pp. 407-415.
8. Hartiati, A., & Mulyani, S. (2015)."The effect of maltodextrin concentration and drying temperature to antioxidant content of sinom beverage powder, Agriculture and Agricultural Science Procedia", 3,pp. 231-234.
9. Jeganathan, G. S., & Naveenkumar, K. (2018)."Material handling management in third party logistics warehouse", International Journal for Research in Engineering Application & Management, 4(8), pp. 1-3.
10. Kabamba, A. M. (2019)."Modeling and Analysis of Queuing Systems in Banks: A Case Study of Banque Commerciale duCongo-BCDC/Mbujimayi", pp.1-10.
11. Kain, R., & Verma, A. (2018)."Logistics management in supply chain–an overview", Materials today:

proceedings, 5(2),pp. 3811-3816.

12. Kalwar, M. A., Marri, H. B., Khan, M. A., & Khaskheli, S. A. (2021).”Applications of Queuing Theory and Discrete Event Simulation in Health Care Units of Pakistan”, International Journal of Science and Engineering Investigations, 10(109),pp. 6-18.
13. Kanagavalli, G., & Azeez, R. (2019).”Logistics and e-logistics management: benefits and challenges”, International Journal of Recent Technology and Engineering (IJRTE), 8(4),pp. 12804-12809.
14. Komashie, A., Mousavi, A., Clarkson, P. J., & Young, T. (2015).”An integrated model of patient and staff satisfaction using queuing theory”, IEEE journal of translational engineering in health and medicine, 3,pp.1-10.
15. Korpysa, J., Halicki, M., & Uphaus, A. (2021).”New financing methods and ICT versus logistics startups”, Procedia Computer Science, 192, pp. 4458-4466.
16. Lourenço, H. R. (2005).“Logistics Management”, In Metaheuristic Optimization via Memory and Evolution (pp. 329-356). Springer, Boston, MA.
17. Mehandiratta, R. (2011). “Applications of queuing theory in health care”, International Journal of Computing and Business Research, 2(2),pp. 2229-6166.
18. Motlagh, M. M., Azimi, P., Amiri, M., & Madraki, G. (2019). “An efficient simulation optimization methodology to solve a multi-objective problem in unreliable unbalanced production lines”, Expert Systems with Applications, 138, 112836.
19. Ng, K. Y. A., Becker, A., Cahoon, S., Chen, S. L., Earl,

P., & Yang, Z. (Eds.). (2015). "Climate change and adaptation planning for ports", London: Routledge.

20. Notteboom, T., & Rodrigue, J. P. (2009). "The future of containerization: perspectives from maritime and inland freight distribution", GeoJournal, 74(1), pp. 7-22.
21. Ristovska, N., Kozuharov, S., & Petkovski, V. (2017). "The impact of logistics management practices on company's performance", International Journal of Academic Research in Accounting, Finance and Management Sciences, 7(1), pp. 245-252.
22. Sagayaraj, A. C., & Amudha, P. (2018). "Different Approach to Minimize the Traffic Congestion by the Application of Queueing Theory", International Journal of Pure and Applied Mathematics, 119(13), pp. 385-393.
23. Sharma, A. K., & Sharma, G. K. (2013). "QUEUEING THEORY APPR OACH WITH QUEUEING MODEL: A STUDY", International Journal of Engineering Science Invention, 2(2), pp. 1-11.
24. Sharma, J. K., (2016)."Operations Research Theory and applications", 6th ed. ,Trinity Press, INDIA.
25. Shojaie, A. A., Haddadi, M., & Abdi, F. (2012). "Hybrid systems modeling in nonstandard queue and optimization with the simulation approach in CNG stations". Research Journal of Applied Sciences, Engineering and Technology, 4(14), pp. 2110-2119.
26. Taha, H. A. (2020). "Operations Research An Introduction", 10th ed., Pearson, UK.
27. Topolšek, D., Čižiūnienė, K., & Ojsteršek, T. C. (2018).

"Defining transport logistics: a literature review and practitioner opinion based approach. Transport", 33(5), pp. 1196-1203.

28. Tudor, F. (2012). "Historical evolution of logistics. Revista de Științe Politice", Revue des Sciences Politiques, (36), pp. 22-32.
29. Valeriano, C. M. C., Ilo, C. K. K., Illescas, M. K. A., Dahilig, J. A. V., & Estember, R. D.(2021). "Queuing Theory: A Case Study in Analyzing the Vaccination Service in Quezon City",pp.2521-2531.
30. Vedaste, R., & Muiruri, P. M. (2021)."Warehouse Management and Operational Performance of Clearing and Forwarding Companies in Rwanda: A Case of Gorrila Logistics Ltd", Journal of Procurement & Supply Chain, 5(2).