Estimating the appropriate number of container yard cranes using queuing theory models

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Abstract :

The research focuses on the problem of allocating the number of cranes in the container terminal yard, and the research aims to estimate the optimal number of container terminal cranes according to the actual need for the work system and to improve the management of container handling activity by estimating the performance indicators of the cranes using mathematical models of the queuing theory to solve this problem, and it was concluded that the number of cranes that are allocated is greater than the actual need for the work system for this activity, which leads to an increase in the total cost resulting from the high cost of servicing the cranes in excess of the need without benefiting from the services of those cranes. The researchers concluded that the use of mathematical models has led to the selection of the appropriate number of yard cranes, and worked to balance the costs of service and waiting, and the decrease in the total cost and improve the management of this activity and recommendations were presented at the end of the research.

Keywords: container yard cranes, theoretical models of waiting queues, Umm Qasr port

تقدير العدد المناسب من رافعات ساحة الحاويات باستخدام نماذج نظرية صفوف الانتظار

(دراسة حالة لمحطات الحاويات في ميناء أم قصر) 1

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المستخلص :

يركز البحث على مشكلة تخصيص عدد الرافعات في ساحة محطة الحاويات ، ويهدف البحث الى تقدير العدد الأمثل من رافعات ساحة محطة الحاويات حسب الحاجة الفعلية لنظام العمل، وتحسين إدارة نشاط مناولة الحاويات، وذلك من خلال تقدير مؤشرات الأداء للرافعات باستعمال النماذج الرياضية لنظرية صفوف الانتظار لحل هذه المشكلة، وتم التوصل الى ان عدد الرافعات الذي يتم تخصيصه اكبر من الحاجة الفعلية لنظام العمل الخاص بهذا النشاط، والذي يؤدي الى ارتفاع الكلفة الكلية الناتجة من ارتفاع كلفة الخدمة للرافعات الفائضة عن الحاجة من دون الاستفادة من خدمات تلك الرافعات. واستنتج الباحثون الى ان استعمال النماذج الرياضية قد أدى الى التوصل الى اختيار العدد المناسب من رافعات الساحة، وعمل على موازنة تكاليف الخدمة والانتظار وانخفاض الكلفة الكلية، وتحسين إدارة هذا النشاط، وتم تقديم التوصيات في نهاية البحث.

الكلمات المفتاحية: رافعات ساحة الحاويات، نماذج نظرية صفوف الانتظار، ميناء أم قصر

[1] بحث مستل من رسالة ماجستير بعنوان (تحسين إدارة اللوجستيات في الموانئ العراقية باستخدام الأنظمة الخبيرة)

1.Introduction

Ports are multi-modal gateways, and critical links because they represent the links between land and water for the transport of goods, and determine the locations and distributions of global supply chains (Notteboom and Rodrigue, 2009:3; Becker et al., 2013:683). Maritime transport contributes to more than 90% of the volume of international trade, which takes place through sea routes and intermodal exchange networks, and it also constitutes focal points for port work (Ducruet et al., 2018:2). Where ports act as platforms within supply chains and global production networks, and support interaction between them on the one hand and regional production and consumption markets on the other, and this is what makes supply chains characterized by dynamism and complexity in order to be able to respond to changes in global trade patterns and consumer preferences, and continuous progress in supply chain management and information technology (Lind et al., 2021:212). Port logistics is a term used to describe the logistics and distribution services based in the port, as it represents the main station for the delivery of those goods, and therefore port logistics consists of a wide range of operations such as cargo handling (loading / unloading), paperwork, monitoring, etc., so The effective operation of port logistics is essential for excellence in global trade and transactions (Meersman et al., 2012:50). Container transport is one of the main pillars of economic globalization and is not limited to discrimination in global trade and transactions (Bernhofen et al. 2016:1), it is also a center for adopting new supply chain practices (Fransoo and Lee, 2013:1; Notteboom and Rodrigue, 2009: 2), Bearing in mind that the logistics management of the container terminal is not considered an easy or one-sided process, but rather a complex process that includes many options for decision-making (Sha et al., 2021:1), because it is linked to many different entities and stakeholders, and dealing is considered With them is part of the day-to-day management of any container terminal, whose primary task is to accurately and quickly organize the exchange of containers between different modes of transport and ensure their safety (Adenso-Díaz et al., 2020:219).

Therefore, this research aims to improve the management of one of the most important logistical activities through the use of queuing theory models as a tool to measure the performance indicators of container yard cranes during the process of handling (loading) containers on external transport trucks, assessing the current situation and presenting performance indicators to those in charge of managing this the activity, and examining the possibility of improving the work system, and submitting proposals in a manner commensurate with balancing waiting costs and service costs, and reducing the total cost of this activity.

2.Research Problem

The current organizations are witnessing a highly competitive global business environment, which requires those organizations to find innovative ways to create value for their customers, in addition to that changing the dynamics of the global market makes any organization compete with other organizations, by focusing on product quality (service / commodity). , cost, and delivery time of that product (Notteboom, 2010:568; Schøyen et al., 2017:265). Therefore, each organization seeks to enhance the demand for its services, overcome inefficiencies and foster innovation in such a way that it does not lag behind its competitors (Pigni et al., 2016:5). The high operating costs and poor customer service that most organizations face are actually due to multiple factors, the most important of which is the weakness of logistics management, as the modern business world coupled with massive competition requires organizations to pay close attention to logistics management as it is one of the main emerging determinants of the organization's profitability and growth (Vedaste and Muiruri,2021:39) Where the management of logistics services in ports reduces the total operating costs, and increases the efficiency of commercial activities, and this is what prompted the management of those ports to find an integrative connection between the concept of logistics management with each of planning, organization, and control, because of its basic implications in the movement of flows human, physical, financial and informatics (Topolšek et al.2018:1196 ; Abdul et al.,2019:37).

Iraqi ports in general and container terminals in those ports in particular suffer from poor management, especially the logistics department, which is responsible for managing activities in the port such as activities (transportation, container handling, container storage, exit and entry of transport trucks to terminals, congestion, etc.).

This research focuses on measuring the performance indicators of the container loading activity on external transport trucks, and the high costs of this activity, which are either due to the allocation of a number of container yard cranes less than the actual need for the work system, which leads to long waiting times for transport trucks, which causes high waiting costs For those trucks, or the high total cost of this activity is due to the allocation of a number of container yard cranes greater than the actual need of the system, which leads to high service costs without benefiting from the services of those cranes.

3.Field of application:

The research is conducted on two container terminals in the port of Umm Qasr 1- Basra Multipurpose Container Terminal (BMT) and 2- Basra Gate Container Terminal (BGT), by measuring the performance indicators of the service channels represented by container cranes in the container yards of the two terminals using mathematical models For queuing theory.

4.Research questions:

The research will be based on a set of questions that revolve around how? And to what extent can:

1- Improving the activity of loading containers on external transport trucks, balancing waiting and service costs, and reducing the total cost by allocating the number of cranes for the Basrah multi-purpose container yard (BMT).

2- Improving the activity of loading containers on external transport trucks, balancing waiting and service costs, and reducing the total cost by allocating the number of container yard cranes at Basra Gate Container Terminal (BGT).

5.Research aims:

1-Allocating the optimal number of container yard cranes (BMT) in Umm Qasr Port, for the purpose of improving the management of the activity of loading containers on external transport trucks, and reducing the total cost by balancing the costs of waiting and service, through the use of queuing theory models.

1- Allocating the optimal number of container yard cranes (BGT) in Umm Qasr Port, for the purpose of improving the management of the activity of loading containers on external transport trucks, and reducing the total cost by balancing the costs of waiting and service, through the use of queuing theory models.

6.Data collection methods

In covering the practical aspect of the research, the researchers relied on field visits for the purpose of collecting study data from the container terminal yards specified in the research.

Where the process included recording (internal arrival times) for 50 external transport trucks to the service channels represented by container yard cranes and (service times) for those channels (cranes).

7.research Design

The research relied on the case study strategy, as it studies a specific phenomenon in a specific place, which is the port of Umm Qasr (container terminals). Where the case study is defined as an experimental inquiry that investigates the contemporary situation (phenomenon) in depth, and within its natural context. Especially when the boundaries are clear between the studied phenomenon and the realistic context of that phenomenon (Yin, 2014:16).

8.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) as follows:

$w_s = W_q + \frac{1}{\mu} \quad ...(1)$	$W_q = \frac{L_q}{\lambda} \quad ...(3)$
$L_s = L_q + \lambda \quad ...(2)$	$W_s = \frac{L_s}{\lambda} \quad ...(4)$

- The total cost per unit of time is calculated through the following equation (Kabamba, 2019):

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

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

9.Queue models used in the research:

9-1. the M/M/c Queue model

The queue model (M / M / c) is applied in the case of multiple service channels, parallel and identical. 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 performance indicators for this model are calculated according to the following equations (Taha, 2020) :

$$P_n = \begin{cases} \frac{\rho^n}{n!} P_0 \,; n < c \\ \frac{\rho^n}{c!\, c^{n-c}} P_0 \,; n \geq c \end{cases} \quad \ldots(6)$$

$$P_0 = \left\{ \sum_{n=0}^{c-1} \frac{\rho^n}{n!} + \frac{\rho^c}{c!} \left(\frac{1}{1 - \frac{\rho}{c}} \right) \right\}^{-1} \;;\; \frac{\rho}{c} < 1 \quad (7)$$

$$L_q = \frac{\rho^{c+1}}{(c-1)!\,(c-\rho)^2} P_0 \quad \ldots(8)$$

$$L_s = L_q + \rho \quad \ldots(9)$$

$$W_q = \frac{L_q}{\lambda} \quad \ldots(10)$$

$$W_s = \frac{L_s}{\lambda} \quad \ldots(11)$$

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

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

$$\lambda_{eff} = \lambda$$

c: the number of service channels

9-2. the G/M/c Queue model

This model is characterized by the fact that the service times follow an exponential distribution at a rate of (1/μ), while the access times to the service channels follow (any distribution other than the exponential distribution), and it is applied when the system has multiple, parallel and stable service channels with an unlimited capacity, and indicators are calculated Performance according to the equations of the (G/M/1) model, with a slight increase in the complexity of some mathematical operations (Shortle et al., 2018:295-299), as follows:

$$W_q(t) = \frac{q_c}{1 - r_0} e^{-c\mu(1-r_0)t} = 1 - \frac{Cr_0^c}{1 - r_0} e^{-c\mu(1-r_0)t} \quad ; t \geq 0 \,; 0 < r_0 < 1 \ldots \quad (29)$$

whereas:

T: represents the arrival period

A(t): The time the service was provided

cμ: average service rate of the system

- As for the rest of the indicators, they are calculated according to equations: (1), (2), (4).

10. Applications

The Matlab language was used to write a program for estimating performance indicators for the mathematical models of the queuing theory specified in the research.

10-1. Estimating the performance indicators of the Basrah Multipurpose Terminal (BMT) container yard cranes.

Table (1) shows the data of the inter-arrival times of the external transport trucks to the service channels in the BMT container yard, and the service times of the service channels represented by the (RTGC) cranes of the specified station container yard.

Table (1) Inter-arrival times data for external transport trucks and service times for cranes in the (BMT) container yard measured in minutes

inter-arrival times	**0.45 0.46 0.58 0.55 0.45 0.47 0.44 0.49 0.42 0.58 0.51 0.57 0.44 0.46 0.44 0.57 1.09 0.35 0.55 1.08 1.03 1.05 0.46 0.51 1.10 0.55 0.49 0.53 1.10 1.03 0.41 0.39 0.43 0.35 2.41 0.50 0.54 0.45 0.58 0.56 0.38 0.52 0.45 0.34 0.54 0.55 0.55 0.53 0.48**
service times	**2.25 2.23 2.18 2.20 2.21 2.19 2.10 2.24 2.17 2.15 2.20 2.16 2.22 2.18 2.24 2.19 2.26 2.14 2.25 2.10 2.14 2.12 2.18 2.25 2.27 2.19 2.23 2.21 2.11 2.15 2.16 2.24 2.11 2.10 2.13 2.26 2.09 2.20 2.19 2.10 2.15 2.18 2.05 2.14 2.16 2.20 2.17 2.24 2.26**

Source: Prepared by researchers based on field visits

As for estimating the performance indicators for the service channels (yard cranes) in the BMT station yard, they are summarized in the following points:

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

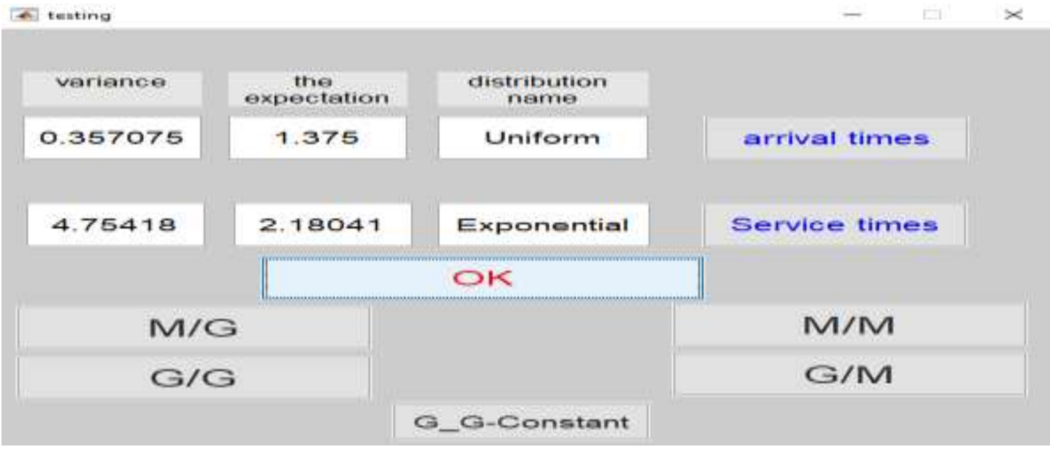
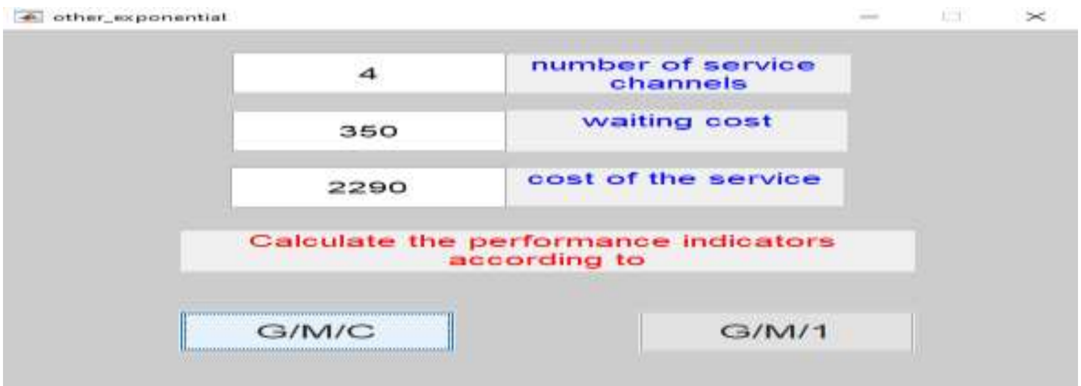


Figure (1) Testing window

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

- According to the (G/M/c) system, the number of service channels (the yard cranes operating during data collection) is entered, which are four cranes, and each of the waiting cost is (350 dinars/minute), and the service cost is (2290 dinars/minute), which were provided by the port administration Umm Qasr, as shown in Figure (2).



Form (2) window for entering the number of service channels and waiting and service costs. Source: Prepared by the researchers based on the outputs of the MATLAB program

- After completing the entry of the number of service channels, waiting and service costs, the (G/M/c) key is selected, and the (GMC) window appears for estimating performance indicators according to the entered data and the specified form, as shown in Figure (3).

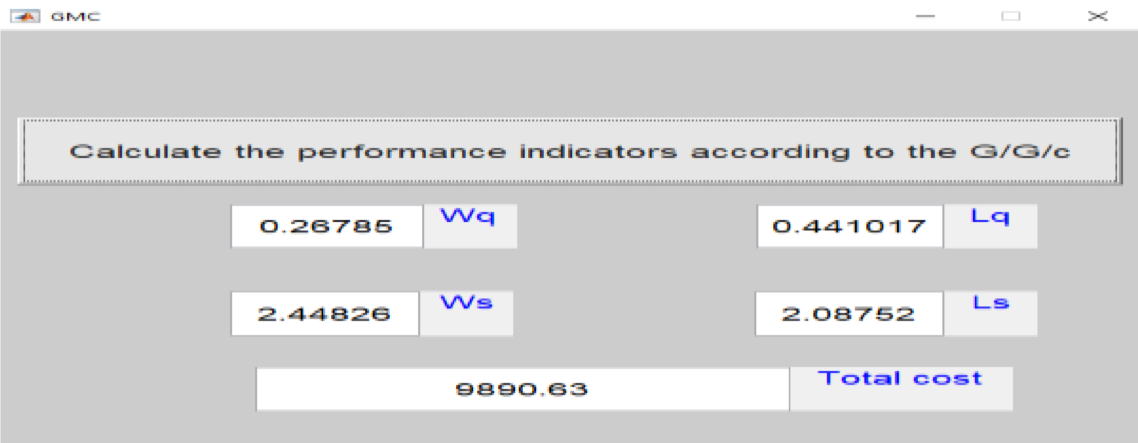


Figure (3) Performance Indicators Estimation Window for Container Terminal (BMT) Yard Cranes. Source: Prepared by the researchers based on the outputs of the MATLAB program

10-1-1.Commenting on the results of the performance indicators and their interpretation:

Through the results presented in Figure (3), which relate to the results of performance indicators estimates for (RTGC) cranes operating in the container terminal (BMT) yard, we find that:

- The average number of trucks in the waiting queue (Lq) is equal to (0.4) trucks, meaning that the waiting queue is almost empty of trucks and is therefore considered acceptable.

The average number of external transport trucks in the system (Ls) is two.

- The average time spent for trucks in the waiting queue (Wq) is equal to (0.26) minutes, which is a short and acceptable time for waiting for transport trucks.

The average time spent for trucks in the system (Ws) is (2.44) minutes.

Through the results of the two performance indicators (Wq, Ws), and after presenting and discussing them with 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 considered acceptable, but it is through the indicator (Ls) It is noted that there is a service channel (crane) vacant (in a state of stopping work and waiting for the arrival of transport trucks). Therefore, the current work system requires an improvement in the process of handling (loading) containers on external transport trucks at the container terminal (BMT) in order to reduce the cost of service And the total cost while maintaining an acceptable level of service delivery.

10-1-2.The proposed model as an alternative to the RTGC crane queuing system in a container terminal (BMT) yard.

The researchers suggest to those in charge of logistics management in the port to improve the process of loading containers onto external transport trucks by reducing the number of yard cranes by one crane (RTGC) so that the new number of cranes is (3 instead of 4) cranes in the specified container yard, and by recalculating Performance indicators for the proposed number of cranes The results of the performance indicators are as shown in Figure (4).

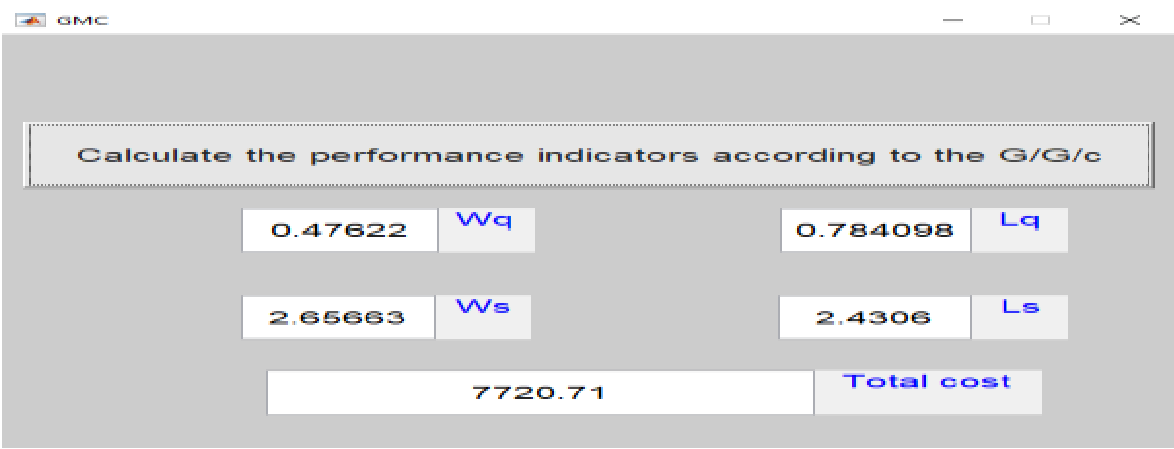


Figure (4) Performance Indicators Estimation Window after Reducing the Number of Container Terminal Yard Cranes (BMT). Source: **Prepared by the researchers based on the outputs of the MATLAB program**

10-1-3.Comparison between the current model and the proposed model

The results of the performance indicators and the estimated total cost of the current model and the proposed model as an alternative to the queuing system for container terminal (BMT) yard cranes are summarized in Table (2).

Table (2) The amount of change in the performance indicators before and after reducing the number of yard cranes at the (BMT) station

queue model	number of service channels	Lq	Ls	Wq	Ws	Cs*K	Cw*Ls	T.C
current model	4	0.441017	2.08752	0.26785	2.44826	9160	730.63	9890.63
proposed alternative model	3	0.784098	2.4306	0.47622	2.65663	6870	850.71	7720.71

Source: prepared by the researcher based on the results of the performance indicators that have been reached

From the results presented in Table (2), it is noted that:

-The number of trucks in the queue (Lq) is approximately one truck.

- The number of trucks in the system (Ls) equals (approximately two trucks in the system).

- The average truck time in line (Wq) is 0.47 minutes.

- The average truck time in the system (Ws) is 2.65 minutes.

- The total cost decreased from (9890.63 dinars/minute) to (7720.71 dinars/minute). That is, the proposed model (reducing the number of yard cranes from 4 to 3) as an alternative to the current queuing system led to a reduction in the total cost by (2169.92 dinars / minute), and with a reduction rate of up to (approximately 22%) of the total cost before reducing the number of cranes in the yard containers.

Through the results of the performance indicators of the proposed model, and after presenting them to those in charge of managing the logistics activities in the port, it was found that each of the number of trucks and the waiting time for those trucks in a row and the queue system after reducing the number of cranes in the yard of a container terminal (BMT), is acceptable, The proposed work system does not require further improvement of the process of handling (loading) containers on external transport trucks at a container terminal (BMT).

10-2. Estimating the performance indicators of the yard cranes of the Basra Gate Container Terminal (BGT).

Table (3) shows the data of the inter-arrival times of external transport trucks to the service channels in the container terminal (BMT) yard, and the service times of the service channels represented by (RTGC) cranes, of the specific container terminal yard.

Table (3) Inter-arrival times data for external transport trucks and service times for cranes in the (BGT) container yard measured in minutes

inter-arrival times	0.55 1.02 0.53 0.56 1.08 1.04 0.50 0.58 1.02 0.57 0.59 0.54 1.56 1.08 0.56 0.58 0.55 1.01 0.58 0.57 0.54 0.56 1.06 1.03 0.53 1.08 1.01 0.55 0.59 0.54 1.18 0.51 1.06 0.51 1.05 1.02 0.52 1.19 1.07 0.59 1.05 0.56 1.02 0.57 0.53 0.52 1.02 0.58 0.59
service times	2.10 2.26 2.17 2.15 2.18 2.20 2.14 2.18 2.15 2.21 2.19 2.12 2.19 2.15 2.22 2.16 2.18 2.08 2.24 2.13 2.15 2.10 2.16 2.20 2.14 2.17 2.22 2.18 2.19 2.10 2.12 2.14 2.16 2.14 2.17 2.13 2.16 2.12 2.15 2.13 2.14 2.16 2.12 2.10 2.15 2.06 2.10 2.20 2.19

Source: Prepared by researchers based on field visits

To estimate the performance indicators for the service channels (yard cranes) in the BGT station yard, they are summarized in the following points:

- After testing the data, it was found that each of the data of the interfacial access times and the service times are distributed exponentially, as their statistics are summarized in Figure (5), and therefore the appropriate queue model is (M/M/C).

Figure (5) Testing window

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

-And after entering the number of service channels (the yard cranes operating during data collection), which are five cranes, and entering each of (the waiting cost is 350 dinars/minute, and the service cost is 2290 dinars/minute, which were provided by the Umm Qasr Port Administration) The performance indicators for this system shown in Figure (6) were estimated.

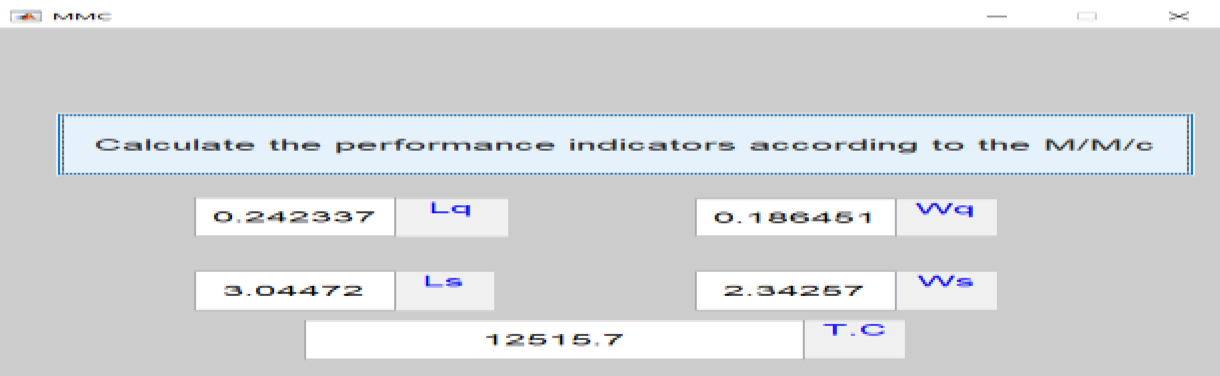


Figure (6) The performance indicators calculation window for the container terminal (BGT) entry gate. Source: Prepared by the researchers based on the outputs of the MATLAB program

Through figure (6), it is noted that the results of the performance indicators (Wq, Ws, Lq), and after presenting and discussing them with those in charge of managing the logistics activities in the port, it was found that each of the waiting time spent by the external transport trucks in the queue or in the system, in addition to The number of trucks in the waiting queue is acceptable, but through the index (Ls) it is noted that there are vacant periods in the work of the yard cranes, so the current work system requires an improvement in the process of handling (loading) containers on the external transport trucks of the container terminal yard (BGT).

10-2-1.The proposed model as an alternative to the crane queuing system in a container terminal (BMT) yard

The researchers suggest to those in charge of logistics management to improve the process of loading containers onto external transport trucks by reducing the number of service channels (yard cranes) (RTGC) by (one crane) so that the new number of cranes is 4 yard cranes operating in the container yard instead of 5 Cranes, and by re-estimating the performance indicators according to the proposed number of cranes, the results of the performance indicators are as shown in Figure (7).

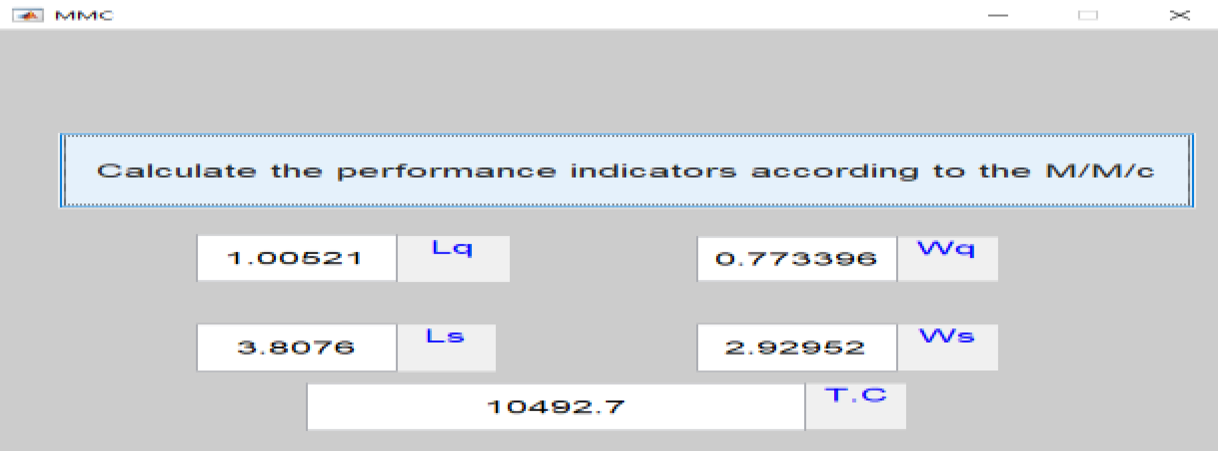


Figure (7) Performance Indicators Estimation Window after Reducing the Number of Container Terminal Yard Cranes (BGT): **Prepared by the researchers based on the outputs of the MATLAB program**

10-2-2.Comparison between the current model and the proposed model

The results of the performance indicators and the estimated total cost of the current model and the proposed model as an alternative to the queuing system for container terminal (BGT) yard cranes are summarized in Table (4).

Table (4) Estimated performance indicators for container terminal (BGT) yard cranes before and after reducing the number of cranes

queue model	number of service channels	Lq	Ls	Wq	Ws	Cs*K	Cw*Ls	T.C
current model	5	0.242337	3.04472	0.186451	2.34257	11450	1065.7	12515.7
proposed alternative model	4	1.00521	3.8076	0.773396	2.92952	9160	1332.7	10492.7

Source: prepared by the researcher based on the results of the performance indicators that have been reached

Through the results of performance indicators, and after presenting and discussing them with those in charge of managing the logistics activities in the port, it was found that each of the number of trucks, and the waiting time spent by external transport trucks in the waiting queue or in the system after reducing the number of service channels (yard cranes) by (One crane) is acceptable, and there is no need to perform additional improvements on the proposed model for the queuing system. In addition to the decrease in the total cost (T.C) from (12515.7 dinars / minute) to (10492.7 dinars / minute), meaning that the amount of the total cost that It was reduced (2023 dinars / minute) by approximately 16% of the total cost before reducing the number of cranes.

11.Conclusions and Recommendations

11-1.Conclusions

Based on the results reached, the conclusions will be presented according to those results, as follows:

1- The conclusion of the Basrah Multipurpose Terminal (BMT) container yard cranes while loading containers on external transport trucks:

The results of the performance indicators of the yard cranes at the Basrah Multipurpose Container Terminal (BMT) for external transport operations showed that the loading operations of the yard cranes were unacceptable due to the presence of vacant service channels (cranes) during work, due to the operation of a number of cranes greater than the actual need, and accordingly the performance was improved By presenting a proposed alternative model for the current queuing system, (reducing the number of cranes in the container yard by one crane) to become (3 instead of 4 cranes). Which showed a tangible improvement in the decrease in the cost of service, which led to a decrease in the total cost, with the stability of the level of service provision. From this we conclude that the proposed model is acceptable, and it is better than the model currently in use, because it leads to a reduction in the total cost due to the decrease in the cost of the service. .

2- The conclusion of the Basra Gate Container Terminal (BGT) container yard cranes while loading containers on external transport trucks:

The results of the performance indicators of the Basra Gate Container Terminal (BGT) yard cranes for external transport operations showed that loading operations are unacceptable, due to the presence of vacant service channels (cranes) during work. Accordingly, the performance was improved by presenting an alternative proposed model for the current queuing system, (reducing the number of cranes in the container yard by one crane) to become (4 instead of 5 cranes). Which showed an improvement in the decrease in the cost of service, which led to a decrease in the total cost, with the stability of the level of service provision, and therefore it turns out that the proposed model is acceptable, and it is better than the model currently in use, because it leads to a reduction in the total cost due to the decrease in the cost of the service.

11-2.Recommendations

1- Adopting the proposed model for the waiting queue system for container terminal (BMT) yard cranes while working on handling (loading) containers on internal transport trucks, by reducing the number of yard cranes by one crane to become (3 instead of 4) cranes, because that It works to reduce the total cost of providing the service for this activity and maintains the level of service provision.

2- Adopting the proposed model as an alternative to the queue system for container terminal (BGT) yard cranes while unloading containers from internal transport trucks and storing them in the yard by reducing the number of yard cranes by one crane because it reduces the total cost of providing service for this activity. . The researchers also recommend the application of queuing models in various logistics activities for the purpose of improving performance and assisting administrations in making correct decisions, including the decision to allocate container yard cranes.

12.Limitations and future research

In this research, mathematical models were applied to specific parts of the logistical activities in isolation from other activities, due to the lack of data at the port administration on successive activities, and the difficulty of collecting such data through field visits due to the lack of time to conduct the research, which forced the researchers to apply these models to all Therefore, we recommend that the researchers, in their future research, apply the network queuing theory to evaluate a group of sequential activities in the port, and we recommend expanding the field of application and applying it in various sectors.

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