دراسة وتحليل كفاءة أداء الرافعات بأرصفة الحاويات بميناء أم قصر باستخدام نظرية صفوف الانتظار

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المستخلص:

يهدف البحث الحالي إلى دراسة وتحليل كفاءة أداء رافعات الرصيف في محطات الحاويات والتي تعد من أهم الأنشطة اللوجستية (مناولة الحاويات) في محطات الحاويات، وذلك باستعمال أحد النماذج الرياضية لنظرية صفوف الانتظار (المتوازية) ، وتحديد العدد الأمثل لقنوات الخدمة (عدد رافعات الرصيف)، والذي يعمل على موازنة تكاليف الانتظار والخدمة وتقليل التكلفة الإجمالية وتقليل فترات الانتظار وزيادة معدل نشاط الخدمة والذي يؤدي في النهاية إلى تعزيز الميزة التنافسية.

اعتمد البحث على النهج المختلط، كما اعتمد على استراتيجية دراسة الحالة من خلال اجراء الدراسة على احدى محطات الحاويات في ميناء ام قصر وهي (محطة حاويات البصرة متعددة الأغراض)، وتم جمع البيانات الخاصة بالبحث من خلال الزيارات الميدانية، واجراء المقابلات مع القائمين على إدارة الأنشطة اللوجستية في الميناء، وتضمنت البيانات المجمعة تسجيل أوقات وصول شاحنات النقل الى قنوات الخدمة المتمثلة برافعات الرصيف لغرض تطبيق النماذج الرياضية لنظرية صفوف الانتظار.

وتوصل البحث الى عدد من الاستنتاجات أهمها ان عملية تخصيص الرافعات لا تتناسب مع كفاءة تلك الرافعات بعد قياس مؤشرات أداء رافعات الرصيف العاملة في محطة الحاويات المحددة بالبحث وتم تقديم التوصيات في نهاية البحث.

الكلمات المفتاحية: كفاءة الأداء ، كفاءة الر افعات ، أرصفة الحاويات ، ميناء أم قصر.

Studying and Analyzing the Performance Efficiency of the Cranes at the Container Berths in the Port of Umm Qasr by Using Queuing Theory

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Abstract:

The current research aims to study and analyze the efficiency of the performance of quay cranes at container terminals, which is one of the most important logistical activities (container handling) at container terminals. This can be done by using one of the mathematical models of the theory of parallel queues, and determining the optimal number of service channels (the number of quay cranes). It works on balancing the costs of waiting and service and reducing the total cost, reducing waiting times, and increasing the rate of service activity, which ultimately leads to enhancing the competitive advantage.

The research relied on the mixed approach, and also relied on the case study strategy by conducting the study on one of the container terminals in the port of Umm Qasr, which is (the multi-purpose terminal of Basra). The data for the study was collected through field visits and interviews with those in charge of managing the logistics activities at the port. The collected data included recording the arrival times of transport trucks to the service channels represented by quay cranes, in order to apply the mathematical models to queuing theory.

The research reached number of conclusions, the most important one was that the process of allocating cranes doesn't fit with the efficiency of the cranes after measuring the performance of quay cranes operating in the container terminal specified for the study. Recommendations presented at the end of the current research.

Keywords: performance efficiency, efficiency of the cranes, container berths, port of Umm Qasr.

Introduction:

The logistics management is among the important managements that contribute to improving the performance of organizations, especially in the maritime transport sector. Because it reduces operational costs and increases the efficiency of logistical activities. Therefore, it requires managements in ports to improve their performance and to keep pace with the changes that occur due to that change in the sizes of ships, the evolution of transport companies, and the competition between shipping lines, by searching for new and innovative methods to achieve its goals.

1.Literature Review

In this part of the research, a few studies are presented To clarify the concept of port logistics and its importance, and show the importance of using the queuing theory in estimating performance indicators.

1-1. Port Logistics

Ports are critical links in the international trade network, and they are multimodal gateways, as they represent the links (nodes) that connect land and water for the transport of goods, and determine the locations and distributions of global supply chains (Becker et al., 2013:683; Ng et al., 2015:2). Maritime transport contributes to more than 90% of the volume of international trade, which takes place through sea routes and multimodal exchange networks, which in turn form pillars of port work (Ducruet et al., 2018:2). The logistics industry is described as a competitive environment, linked to the phenomenon of globalization, which requires organizations to be more flexible, perform more, and constantly search for cost reductions (Jeganathan and Naveenkumar, 2018:433). Port logistics is also 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 commodities. Therefore, port logistics consists of a wide range of operations such as cargo handling (loading / unloading), assigned paperwork, monitoring, etc., Accordingly, 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 not only of differentiation in global trade and transactions, but also of economic globalization (Bernhofen et al. 2016:1).

1-2. 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). As the theory uses a set of techniques to analyze systems that often have competition for resources, and thus it provides special tools for analyzing the critical factors for the expected long queues in organizations that provide services, through (queue, the expected waiting time for each queue) (Bahaweres et al., 2017:2), and therefore it represents the most used tool for solving problems of waiting systems, through which the optimal solutions are reached in the form of performance measures (Kalwar et al., 2021: 7). 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 are often used when making decisions related to Work on the type and quantity of resources needed to provide the service, and it also works on the analysis of 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, management science, and industrial engineering (Sharma and Sharma, 2013: 1).

The use of queuing theory as a tool for estimating performance indicators for different service channels enables managers to make better decisions in an attempt to reduce waiting time through optimal planning for the use of equipment, which reflects positively on productivity, service, and waiting time (Shojaie et al., 2012: 2110). Therefore, the current study will

attempt to use mathematical models of queuing theory to evaluate the performance of quay cranes for the purpose of estimating the optimal number of those cranes, in an attempt to reach the best decisions related to logistics management (Motlagh et al., 2019:3).

2. Research methodology

2-1. Research problem

The process of handling containers in the port is among the important logistical activities in the port. The efficiency of the ports is measured through services they provide, and this service of unloading containers from the ship and loading them on transport trucks is one of the most important logistical activities that are carried out by quay cranes.

The efficiency of the port depends on the efficiency of the equipment operating in that port. The higher the efficiency of the equipment, the more that efficiency is reflected in the general efficiency of the port itself. Thus, more profits are achieved, costs are reduced, and the level of service delivery is improved.

Most of the ports, face the problem of poor performance and a decline in the level of service delivery due to weak departments that do not adopt mathematical methods in making daily decisions, and one of the most prominent of these problems is the allocation of the number of cranes to handle containers. In this research, the problem of allocating the number of quay cranes for container handling will be studied to improve the performance of this activity, provide better services, and reduce costs (waiting, service, and total cost).

2-2. Field of application

The research was conducted on the Basrah Multipurpose Terminal (BMT) in the port of Umm Qasr, by measuring the performance indicators of the service channels represented by the container quay cranes at the aforementioned container terminal using one of the mathematical models of the queuing theory.

2-3.Research question

The current research will depend on the following question: Can the performance of quay cranes be improved during the process of handling (unloading) containers from the ship and loading them on transport trucks at the Basra Multipurpose Terminal (BMT)?

2-4. research aim

The research aims to work on improving the process of handling (unloading) containers from the ship and loading them on transport trucks through studying and analyzing the efficiency of the dock lifts and estimating their performance indicators at Basra Multipurpose Terminal (BMT).

2-5. 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 berths of the container terminals specified in the research. Waiting (parallel) and estimating the performance indicators of the quay cranes for the station specified in the current research and determining the optimal number of quay cranes.

2-6. Research Design

The current 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 can be defined as an experimental inquiry that attempts to research the case more deeply, and within its natural context, especially when the boundaries are clear between the phenomenon under study and its realistic context (Yin,2014:16). The current study relied on the mixed method (Mixed Methods). This is done by combining quantitative and qualitative research methods, where the mixed method enables us to comply with the prevailing research requirements in order to reach valuable results, especially if they are based largely on the researcher's experience in the researched issues, as well as benefiting from the most valuable features of each style, learning and broader

understanding, and conducting the development of a comprehensive knowledge base (Schulze, 2003:19).

The current research, within the concept of the mixed approach, will focus on the use of the (Dominant-less dominant Design) approach, through the use of the quantitative approach. Researcher interviews and observations - a supportive and complementary approach to the quantitative approach (Saludadez and Garcia, 2001:1).

3. The general equations through which performance indicators are estimated

The following mathematical formulas show the relationship between the performance indicators of the queuing models, as indicated by equations (1), (2), (3), (4) (Sharma, 2016:568):

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

The total costs per unit of time can also be calculated through the following equation (Kabamba, 2019:6):

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

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

4. The queue model used in the research

The M/M/c model is used in estimating the performance indicators of quay cranes at container terminals, because each of the recorded arrival times and service times follows an exponential distribution, and (the number of quay cranes is greater than one). In addition to the number of serviced units

(Transport trucks) is not limited due to the continuation of handling operations for ships anchored on the docks of the container terminals specified in the search.

(M/M/c) Queue model

A queue model (M / M / c) is applied when there are multiple parallel and identical service channels (c >1), service (μ), and performance indicators for this model are calculated according to the following equations: (Taha, 2020:675-676).

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

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

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

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

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

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

إذ أن:

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

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

$\lambda_{eff} = \lambda$

c: تمثل عدد قنوات الخدمة

5. Practical Framework

The program for estimating the performance indicators of the mathematical model used in the current research related to the queuing theory was written using the Matlab language.

5-1. Basra Multipurpose Terminal (BMT)

The Basrah Multipurpose Terminal (BMT) consists of one berth (resulting from the merger of berths 15 and 16), and is equipped with five mobile cranes for the purpose of handling (loading and unloading) containers to and from container ships, moored on any of the two aforementioned berths, and below are the results of estimating the performance indicators of the berth cranes.

5-2. Estimating the performance indicators of the quay cranes operating at the Basra Multipurpose Terminal (BMT):

Table (1) shows the data of the inter-times for the arrival of the transport trucks to the service channels at the container terminal (BMT), represented by the berth cranes, which handle (unloading) the containers from the ship, and load them on the transport trucks, and the service times for those cranes.

Table (1) Data of inter-arrival times and service times for transport trucks at the container terminal (BMT) berth, measured in minutes

inter-arrival times	**1.20 1.26 1.27 1.15 1.18 1.10 1.12 1.17 1.15 1.25 1.14 1.16 1.19 1.20 1.12 1.29 1.18 1.16 1.28 1.13 1.14 1.15 1.14 1.23 1.17 1.10 1.16 1.19 1.13 1.21 1.18 1.25 1.21 1.24 1.20 1.28 1.15 1.22 1.13 1.25 1.12 1.14 1.11 1.26 1.15 1.22 1.19 1.13 1.17**
service times	**3.11 3.09 3.08 3.05 3.13 3.06 3.14 3.12 3.08 3.10 3.15 3.16 3.09 3.15 3.07 3.06 3.20 3.14 3.14 3.18 3.15 3.16 3.14 3.18 3.21 3.10 3.07 3.15 3.17 3.12 3.19 3.14 3.06 3.09 3.10 3.11 3.07 3.14 3.23 3.13 3.05 3.17 3.12 3.10 3.12 3.10 3.11 3.17 3.15**

Source: prepared by the researchers based on field visits

As for estimating the performance indicators of the quay cranes at the (BMT) station, they were summarized in the following points:

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

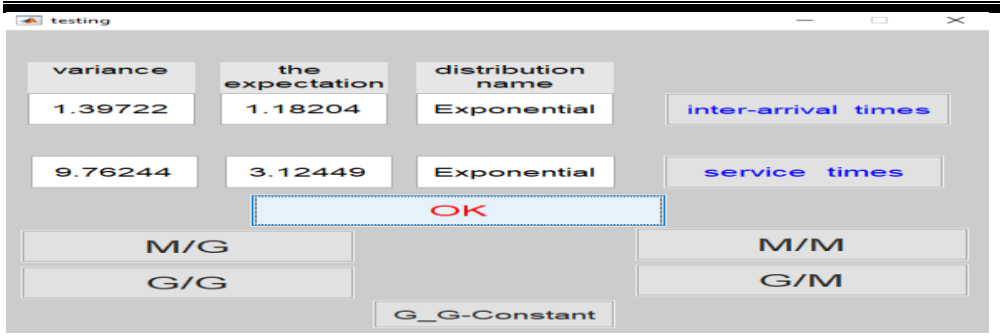

Figure (1) Good Conformance Test Window for BMT Quay Data
(**Source**: prepared by the researchers based on the outputs of the MATLAB program)

- According to the (M/M/c) system, after entering the number of service channels (berth cranes) (n=5) and entering both (the waiting cost is 825 dinars/minute, and the service cost is 3325 dinars/minute, which was estimated by the Umm Qasr Port management. The performance indicators for this system shown in Figure (2) and summarized in Table (2).

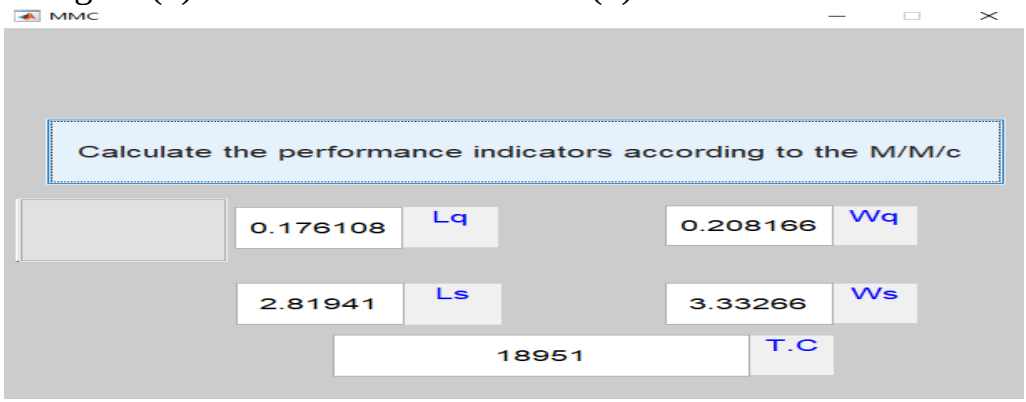

Figure (2) Performance Indicator Estimation Window for Container Terminal (BMT) Quay Cranes
(**Source**: prepared by the researchers based on the outputs of the MATLAB program)

5-3. Results Discussing of performance indicators and their interpretation:

Through what has been presented of the results of estimating performance indicators for mobile cranes at the container terminal (BMT), and after presenting and discussing them with

those in charge of logistics management at the port, researchers to the following:

- The average number of trucks in the queue (Lq) is equal to 0.17 trucks. This approximates the absence of trucks in the queue, and therefore it is a good indicator, acceptable and appropriate to the nature of the work of transport trucks.
- The average number of trucks in the system (Ls) is 2.8 trucks, and this indicator indicates that there are approximately 3 trucks in the system, and since the number of service channels is 5 cranes, this indicator indicates the presence of vacant service channels during work, which causes wasted costs Not necessary in the working system (additional service cost).
- The average waiting time (Wq) for trucks in the waiting line is 0.20 minutes, and it is noted that it is a short and acceptable waiting period in relation to the nature of the work of trucks.
- The average waiting time (Ws) for trucks in the system is 3.33 minutes, which is the time spent by a truck waiting while receiving service.

Based on the above results, it appears that the current system is unacceptable, because the company (Umm Qasr Port) under this system bears an additional cost resulting from operating the cranes, although they are vacant most of the working time, and therefore requires an improvement in the management of the current service system.

6. Proposed models as an alternative to the current queue model at the container terminal (BMT) at Umm Qasr Port:

In order to reduce the waiting time (stopping periods) for quay cranes, taking into account the continuation of work with the same efficiency, and maintaining an acceptable level (stability or reduction) of the total cost, it was proposed to reduce the number of service channels and to present two proposed models as an alternative to the current queue model, to reach the optimal level of service, discussing the results for each of the two proposed models, and choosing the best model among them, as follows:

6-1. The first proposed model:

It includes reducing number of service channels (Quay Cranes) by one crane, so that number of cranes used is (4 instead of 5 cranes). To estimate the performance indicators of the proposed model, the (M/M/c) model is applied to the proposed number, so the results Performance indicators as shown in Figure (3).

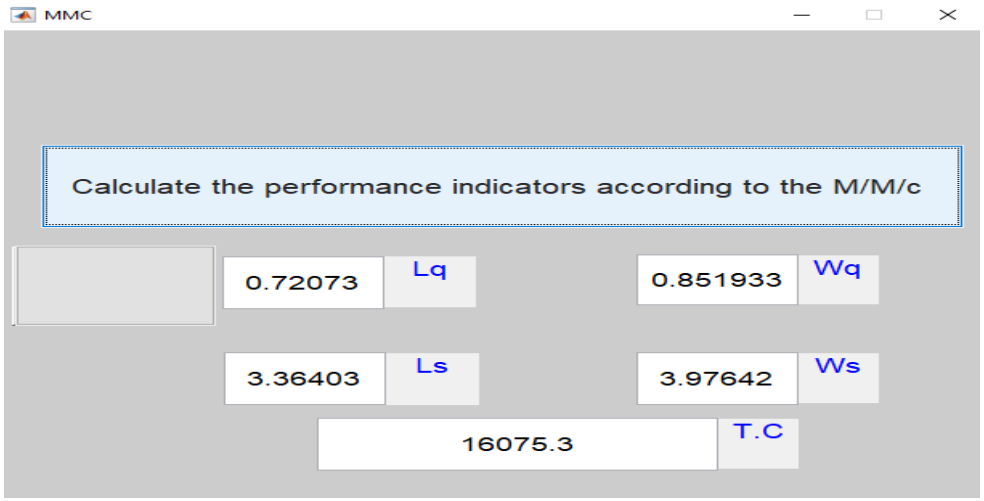

Figure (3) Performance indicators calculation window for the first proposed model for container terminal (BMT) quay cranes (**Source**: prepared by the researchers based on the outputs of the MATLAB program)

-According to Figure (3), the following is noted:

- The average number of transport trucks in the queue (Lq) = 0.7, meaning that there is almost one truck in the queue.
- The average number of transport trucks in the system (Ls) = 3.36 trucks, meaning that there are approximately three trucks in the system (the number of trucks in the queue + the number of trucks receiving service).

-The average time in line for trucks (Wq) = 0.85 minutes and closes to 1 minute.

-The average time taken for transport trucks in the system (Ws) = 3.97 minutes and is close to 4 minutes.

- The decrease in the total cost (T.C.) from (18951 dinars/minute) to (16075.3 dinars/minute), meaning that the reduction in the number of service channels (from 5 to 4) cranes led to a decrease in the total cost by (2875.7 dinars/minute), by a percentage Approximately 15% compared to the cost before reducing the number of cranes, and the reduced percentage is transformed from a lost cost into profits added to the profits realized from this activity.

6-2. The second proposed model: It includes reducing the number of service channels (berth cranes), by two cranes, so that the number of cranes used is (3 cranes instead of 5 cranes), and by applying the waiting queue model to the proposed number of cranes, researchers estimate the performance indicators of the second proposed model as an alternative to the queue system , and as shown in Figure (4).

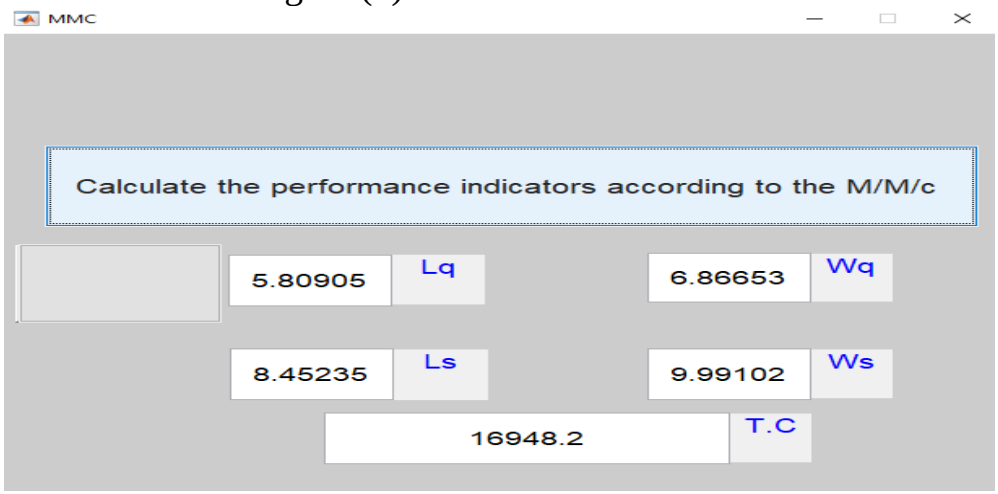

Figure (4) Performance indicators calculation window for the second proposed model for container terminal (BMT) quay cranes (**Source**: prepared by the researchers based on the outputs of the MATLAB program)

According to figure no.4, the following is noted:

- The average number of transport trucks in the waiting queue (Lq) = 5.8 trucks, which indicates that the number of trucks in the waiting queue is approximately 6 trucks.

- Average number of transport trucks in the system (Ls) = 8.4 trucks.
- The average time spent by transport trucks in the waiting queue (Wq) = 6.8 minutes, meaning that the time spent by transport trucks in the waiting queue is approximately 7 minutes.
- Average time taken for transport trucks in the system (Ws) = 9.9 minutes.

Total cost (T.C.) = 16948.2 dinars/minute.

6-3. Comparison between the current model and the proposed models:

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

Table (2) Estimated performance indicators for the current model and the two proposed models

queue model	number of service channels	Lq	Ls	Wq	Ws	Cs* K	Cw*Ls	T.C
current model	5	0.176108	2.81941	0.208166	3.33266	16625	2326	18951
The first proposed model	4	0.72073	3.36403	0.851933	3.97642	13300	2775.3	16075.3
The second proposed model	3	5.80905	8.45235	6.86653	9.99102	9975	6973.2	16948.2

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

From Table (2), researchers notice the following:

The results of the performance indicators of the Basrah Multipurpose Container Terminal (BMT) for internal transport operations showed that the loading and unloading operations of the quay cranes are unacceptable, due to the presence of vacant service channels during work, which in turn leads to additional costs incurred by the port resulting from the operation of a larger number of quay cranes. From the actual need for the work system, and accordingly the performance was improved by presenting two proposed models as an alternative to the current queuing system, as the first proposed model includes reducing the number of cranes by one crane, while the second proposed model includes reducing the number of cranes by two cranes, and performance indicators have varied For the two proposed models, as shown in Table (4), which show the amount of change in the performance indicators for each model compared to the current model in order to improve the work system and reduce costs. By comparing these models, researchers find out the following:

- The queue system currently in force (before reducing the number of service channels) is acceptable in terms of the number of trucks in the queue (Lq), as well as acceptable in terms of the time spent by transport trucks in the queue (Wq), and in the system (Ws). However, through the (Ls) index, it is noted that the number of trucks in the system is approximately 3 trucks, which means that there are two service channels in a state of idleness (rest periods) waiting for the transport trucks, with the continuation of the costs of servicing those two cranes. Thus, the system current is not acceptable.
- The first proposed model, which includes reducing the number of cranes by one crane, from 5 to 4 cranes, the performance indicators according to the new number of cranes have shown that there is a decrease in the total cost by approximately 15%, which is a percentage of achieving high profits through the continuous work of the container handling process It also maintained the level of service provision within acceptable limits, and the results, after presentation and discussion with

those in charge of managing logistics activities, showed the acceptability of the number of trucks in the queue and the time for service provision. Accordingly, we conclude that the proposed system is acceptable.

- The second proposed model, which includes reducing the number of cranes by two cranes from 5 to 3 cranes, the performance indicators, according to the new number of cranes, have shown that there is an increase in the waiting cost by a percentage greater than the decrease in the cost of service, which was reflected in the increase in the total cost, and a decline in the level of service provision . The results, after presenting and discussing them with those in charge of managing the logistics activities, showed that the number of trucks in the waiting queue, the system, and the time for providing the service were unacceptable. Accordingly, we conclude that the second proposed model is unacceptable.

7. conclusions

According to the research results, researchers conclude that the first proposed model as an alternative to the current queuing system for quay cranes at Basra multi-purpose container terminal is the best model among the models (the current and the second proposed model) because it works to balance the costs of waiting and service, and reduces the total cost and maintains an acceptable level of Service and reduces waiting time for transport trucks.

8. Recommendations

Based on the conclusions reached according to the results of the performance indicators of the quay cranes in Basra multi-purpose terminal, researchers recommend the following:

The application of the first proposed model for the work of berth cranes at the (BMT) container terminal, which includes reducing the number of cranes by one crane (from 5 to 4) cranes, because this leads to a decrease in the total cost of providing the service, which leads to achieving high profits for the port through the continuity of work for the cranes.

9. Research Limitations

There is a process of involvement and overlapping in the internal and external transport operations in the logistics service activities that take place inside the port (container handling operations at the dock) resulting from the nature of the work, so the researchers were unable to use closed models (limited capacity) in calculating performance indicators for the aforementioned service channels The researcher relied on open models (unlimited capacity) in the process of estimating performance indicators because they are the most appropriate in such cases.

10. Future Research

The researchers recommend the use of closed models (limited capacity) in the systems that can use these models to evaluate their performance, and the use of mathematical models of the network queuing theory in the case of the availability of data for the successive activities of the port administrations in order to evaluate and estimate the performance indicators for a group of activities in the port.

References:

1. Bahaweres, R. B., Fitriyah, A., & Rozy, N. F. (2017). 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.
2. 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..
3. Bernhofen, D. M., El-Sahli, Z., & Kneller, R. (2016). Estimating the effects of the container revolution on world trade". *Journal of International Economics*, 98,pp. 36-50.
4. Ducruet, C., Cuyala, S., & El Hosni, A. (2018). Maritime networks as systems of cities: The long-term interdependencies between global shipping flows and urban development (1890–2010), *Journal of Transport Geography*,66,pp. 340-355.
5. 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.
6. Kabamba, A. M. (2019). Modeling and Analysis of Queuing Systems in Banks: A Case Study of Banque Commerciale duCongo-BCDC/Mbujimayi", pp.1-10.

7. 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.
8. Meersman, H., Van de Voorde, E., & Vanelslander, T. (2012). Port congestion and implications to maritime logistics. *In Maritime Logistics. Emerald Group Publishing Limited*,pp.47-69.
9. Mehandiratta, R. (2011). Applications of queuing theory in health care. *International Journal of Computing and Business Research*,2(2), 2229-6166.
10. 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, pp.1-40.
11. 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.
12. 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.

13. Saludadez, J. A., & Garcia, P. G. (2001),"Seeing our quantitative counterparts: construction of qualitative research in a roundtable discussion", In Forum Qualitative social research /Forum: Qualitative Social Research,2(1),pp.1-11.

14. Schulze, S. (2003). Views on the combination of quantitative and qualitative research approaches. *Progressio*,25(2),pp.8-20.

15. Sharma, A. K., & Sharma, G. K. (2013). Queueing Theory Approach with Queueing Model: A study. *International Journal of Engineering Science Invention*, 2(2),pp.1-11.

16. Sharma, J. K., (2016).Operations Research Theory and applications, 6th ed. ,Trinity Press, INDIA.

17. Shojaie, A. A., Haddadi, M., & Abdi, F. (2012). Hybrid systems modeling in non-standard queue and optimization with the simulation approach in CNG stations. *Research Journal of Applied Sciences, Engineering and Technology*,4(14),pp.2110-2119.

18. Taha, H. A. (2020). Operations Research An Introduction,10th ed., Pearson ,UK.

19. Yin,R.,K.,(2014). Case study research: Design and methods,5th ed., *Sage*, *The Canadian Journal of Program Evaluation*. UK.