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KING ABDULLAH PORT (KAP) SIMULATION MODEL

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ABSTRACT

The study was conducted to evaluate the efficiency of the King Abdullah port in Saudi Arabia. The study was interested in evaluating the optimal use of the port. The study used a different mathematical model to simulate and predict the future optimal use of the port to ensure that there was a maximum gain in interest. In this work, quantitative research method was used. The model used the mean absolute percentage error and the root mean square error to evaluate the efficiency of the forecast for TEU capacity utilization. The data were collected from primary and secondary source. The study population consists of four ports located in Saudi Arabia. These ports are the Jeddah Islamic Port (JIP), King Abdullah Port (KAP), Jubail Commercial Port and King Abdul-Aziz Port (Dammam). The period of research data applied for this study is 13 years from 2012 to 2025. Results have shown that the model that optimizes port utilization is King Abdullah's economic city port, as the lowest average absolute percentage error of 0.037719389 was observed.

CCS Concepts

• Information systems→Database management system engines • Computing methodologies→Massively parallel and high-performance simulations.

INTRODUCTION

With the rise of globalization, there has been an increasing demand for adjustments to international trade relations, and part of the measures that have been introduced to ease business relations includes the definition and exploitation of free zones (FZs) [1]. In addition, there is approximately around 4,500 areas around the world have been designed as FZs, with more than 135 countries exploring a new approach to tradeoffs [2]. Ideally, the FZs operate

without the traditional local customs unit protocol, which would require the payment of taxes and different customs duties, making them more attractive to businesses [3].

Due to the nature of the business and the operating framework, most of the zones are set up around transport terminals, commonly ports, airports and seaports [4]. There are several merits in the addition of the FZs, as such facilities mostly benefit from reduced red tape in both company registration and employment, as immigration and documentation requirements are toned down [5]. Usually, for any organization, business growth is generally characterized by the number of units handled, the accrued profits margins, the number of employees, and if any, the stock exchange earnings. For FZs it is focused the number of Twenty-Foot Equivalent Unit (TEU)'s handled which signifies the scale of operations for FZs [6].

There are several aspects that are reflected in defining the importance of growth, including reduced operating costs, which are often associated with higher production levels of ports and FZs. Filina-Dawidowicz et al. [7]recognizes that increasing the number of annual TEUs handled increases the likelihood of an exponential increase in profit margins. As such, tapping the benefits associated with FZs would not only boost the port business environment, but would also increase the chances of making more of a global impact on the port business. In addition, the most common advantages associated with FZs in the context of a port are intended to increase its profitability and sustainability, as well as the output of TEUs [8].
Furthermore, Akhavan [9] stated that FZs are known to receive a significant share of government incentives, including good tax incentives, tariffs and regulatory incentives, and these measures have been known to significantly reduce operating costs Moreover, Yang and Chen [10] study found that the FZs have been associated with state-of-the-art infrastructure that significantly boosts both the international and local labor pools and the rated organizations by increasing work-friendliness. Likewise, the work of Moberg [11] acknowledges that the business environment presented by the FZs tends to increase the level of innovation that stimulates the region's intention to become a smart city, thus enhancing the nature of business operations. In addition, Onele [12] stated that FZs is known for its relatively friendly operating legal frameworks, which seem to welcome more companies. According to Hamilton & Webster [13], the legal benefits associated with the FZs include a variety of tax exemptions, the right to repatriate a business in whole or in part, no currency restrictions and free transfer of funds.

Port capacity optimization is the measure that is put in place to ensure that the various activities within ports are carried out seamlessly with the aim of providing key safety and increasing returns [14]. The main advantages of increasing optimization are increased profit as a rest on the increased scale of trade as well as improved safety. In addition, a port that has optimized its activities to handle more containers improves trade and related activities [14]. Moreover, ports with optimum infrastructure tend to have a shorter container handling time in turn to address port congestion and ensure maximum use of space. Similarly, a higher level of production tends to increase the trust of the

business as a sign of dependence. By increasing the scale, the port will be chosen by the owner of the business and, in turn, increase its competitiveness in the market [14].

Ideally, facilities such as the King Abdullah Port (KAP) [15] have always taken advantage of both national and international inception, thus increasing their overall performance and the scale of their operations. The throughput capacity of KAP is 20 million TEUs, with only 2.8 million currently in use. The port is faced with a low market share of exports and imports compared to other ports in Saudi Arabia. Based on this, the port has not reached the maximum level of utilization of its resources and spaces. Thus, this work was done to analyze the exploitation of the Free Zone in order to promote the commercial interest in the KAP. In this case, the benefits accrued by the FZs are focused on facilitating KAP to optimize its operations to the fullest extent possible.

METHODOLOGY

This work has used quantitative research method. The model will use the mean absolute percentage error and the root mean square error in evaluating the efficiency of the forecast in utilization of the TEU capacity. For the series Y_1, Y_2, Y_3, Yt, the forecast for the preceding value Y_{t+1} let say F_{t+1} is based on the weights α and 1-α to the recent observation Y_t and forecast F_t respectively, where alpha is the smoothing constant. The form of the model is shown in Equation 1.

$F_{t+1}=Ft+\alpha\ (Y_t-F_t)$	(1)

The size of α used has a great influence on the forecast. The best value of α corresponding to the minimum mean square error (MSE) is usually used. The root mean square error (RMSE) and the mean absolute percentage error (MAPE) have helped to evaluate the performance of the various approaches and are shown as Equation 2 and Equation 3, respectively.

$MAPE=1/n(\Sigma\lvert(Y_t-F_t)/Y_t\rvert)$	(2)
$RMSE=\sqrt{(1/n\Sigma\ (Y_t-F_t)\text{^}2)}$	(3)

Where Y_t is the TEU in different years and F_t is the forecasted TEU in the corresponding years and n is the number of years used as forecasting period.

For this work, the study population consists of four ports located in Saudi Arabia. These ports include Jeddah Islamic Port (JIP), King Abdullah Port (KAP), Jubail Commercial Port and King Abdul-Aziz Port (Dammam). The applied data research period for this study is 13 years from 2012 to 2025. The data will be used to predict port utilization in order to optimize the use of the King Abdullah port. The data for the this study were obtained from the primary source, King Abdullah Port (KAP), and the historical data from the DP World Internet. The secondary data were attained from

The Saudi Statistical Authority and the Ports Authority. In this work, forecasting was carried out as inferential statistics. Statistical analysis included root mean square error (RMSE) and the mean absolute percentage error (MAPE).

RESULT AND DISCUSSION

Correlation Between Square Meter And TEU

The result in Table 1 shows the correlation between the square meter and TEU twenty feet equivalent units. From this result the correlation coefficient between square meter and TEU was 99.18%. This indicates that there is a strong poisitive relationship between the Jebel Ali Free Zone Authority (JAFZA) square meter and the JAFZA capacity in TEU. Based on the evaluation result of the port in Table 2, it is found that there are large spaces that are not utilized within the port such as King Abdullah Port (KAP) Bounded logistic park, King Abdullah Economic City (KAEC BRZ), Industry Village 5 (IV5).

Table 1. Correlation Between Square Meter And TEU's

Year	JAFZA Sqm	JAFZA TEU's
1990	2,100,000	1,000,000
1999	8,100,000	2,800,000
2005	27,900,000	7,620,000
2007	42,200,000	10,650,000
2010	42,200,000	11,600,000
2015	67,200,000	15,200,000
		98.18%

Table 2. Free Space Location, Sqm And TEU's

Location	Sqm	TEU's
KAP Bounded logistic park	750,000	160,000
King Abdullah Economic City (KAEC BRZ)	3,300,000	680,000
Industry Village 5 (IV5)	7,000,000	1,100,000

Forecast Analysis TEU KAP BRZ

The result in Table 3 indicate that the root mean square error (RMSE) of the forecast of TEU's in King Abdullah port was 19,186,716,519, and the Mean absolute percentage error (MAPE) was 0.045653706, which was less than one.

This is an indication that the forecast of the KAP capacity should increase by 2025. The market share of KAP bound logistic park will have raised by 6% of the total current capacity.

Table 3. *TEU's KAP BRZ Forecast*

Year	TEU's	KAP BRZ TEU's	Total	RMSE	MAPE
2013	26,336		26,336		
2014	497,635		497,635		
2015	1,277,293		1,277,293		
2016	1,363,645		1,363,645		
2017	1,668,104		1,668,104		
2018	2,266,428		2,266,428		
2019	2,282,103	40,443	2,322,546	1,635,636,249	0.017722
2020	2,317,626	90,997	2,408,623	8,280,454,009	0.039263
2021	2,535,669	157,728	2,693,397	24,878,121,984	0.062204
2022	2,756,158	157,728	2,913,886	24,878,121,984	0.057227
2023	2,978,247	157,728	3,135,976	24,878,121,984	0.05296
2024	3,200,964	157,728	3,358,692	24,878,121,984	0.049275
2025	3,854,130	157,728	4,011,858	24,878,121,984	0.040924
			RMSE	19,186,716,519	
			MAPE	0.045653706	

Forecast Analysis TEU KAEC BRZ

Based on Table 4, the result of King Abdullah's Economic City model (KAEC) on increasing of the TEU capacity of KAP indicates that the root

mean square error (RMSE) was 1,475,626,033 while the Mean absolute deviation was 0.037719389. This shows that the King Abdullah Economic City forecast method increases the TEU capacity of KAP. The total capacity for KAEC BRZ will raise its market share by 6% of its total market share.

Table 4. TEU's KAEC BRZ Forecast

Year	TEU's	KAEC BRZ TEU's	Total	RMSE	MAPE
2013	26,336		26,336		
2014	497,635		497,635		
2015	1,277,293		1,277,293		
2016	1,363,645		1,363,645		
2017	1,668,104		1,668,104		
2018	2,266,428		2,266,428		
2019	2,282,103		2,282,103		
2020	2,317,626		2,317,626		
2021	2,535,669		2,535,669		
2022	2,756,158	101,108	2,857,266	10,222,827,664	0.036684399
2023	2,978,247	113,088	3,091,335	12,788,895,744	0.037971 33
2024	3,200,964	126,487	3,327,450	15,998,708,196	0.039514971
2025	3,854,130	141,475	3,995,603	20,014,609,729	0.036706857
			RMSE	14,756,260,333	
			MAPE	0.037719389	

Forecast Analysis Industry Village 5

Based on Table 5, the results of model of industry village five on increase of the TEU capacity of KAP indicate that root mean square error (RMSE) was 48802000000 while the Mean absolute deviation (RMSE) was 0.05709657. This indicates that the industry village five forecast method increases the TEU capacity of KAP. The market share for industry village five ports will increase from the original market share by 7% of the total market share.

Table 5. TEU's Industry Village 5 Forecast

Year	TEU's	IV5 TEU's	Total	RMSE	MAPE
2013	26,336		26,336		
2014	497,635		497,635		
2015	1,277,293		1,277,293		
2016	1,363,645		1,363,645		
2017	1,668,104		1,668,104		
2018	2,266,428		2,266,428		
2019	2,282,103		2,282,103		
2020	2,317,626		2,317,626		
2021	2,535,669		2,535,669		
2022	2,756,158	202,216	2,958,374	4.0891E+10	0.073368798
2023	2,978,247	226,175	3,204,422	5.1155E+10	0.075942324
2024	3,200,964	252,973	3,453,937	6.3995E+10	0.079030255
2025	3,854,130	282,946	4,137,076	8.0058E+10	0.073413715
			RMSE	4.8802E+10	
			MAPE	0.05709657	

The Overall Forecast Analysis Of Total Increase In TEU's Capacity

The analysis of the total capacity increase on TEU forecast analysis is shown in Table 6. Thus, based on Table 6, it can be observed that he root mean square error (RMSE) for the 160,261,659,796 and the mean absolute percentage error (RMSE) of 0.110315583596. This indicates the realization of full optimization of the KAP utilization through various model show an

increase in TEU capacity. The correlation coefficient between the TEU of KAP and total forecast utilization was 0.986496. This means that there is strong relationship between the TEU utilization and the models used to forecast the port utilization. From the analysis, the market share for King Abdullah Port (KAP) TEU's will have increase by 10% of its total current market share. This shows that the KAP TEU market share will have raised to 10% by the year 2025.

Table 6. Overall Forecast Analysis

Year	TEU's	Total	RMSE	MAPE
2013	26,336	26,336		
2014	497,635	497,635		
2015	1,277,293	1,277,293		
2016	1,363,645	1,363,645		
2017	1,668,104	1,668,104		
2018	2,266,428	2,266,428		
2019	2,282,103	2,322,546	1,635,636,249	
2020	2,317,626	2,408,623	8,280,454,009	
2021	2,535,669	2,693,397	24,878,121,984	0.0177218119
2022	2,756,158	3,217,210	212,568,946,704	0.0392630217
2023	2,978,247	3,475,238	247,000,054,081	0.0622037025
2024	3,200,964	3,738,152	288,570,947,344	0.1672806857
2025	3,854,130	4,436,279	338,897,458,201	0.1668736676
		RMSE	160,261,659,796	0.1678206940
		MAPE	0.110315583596	0.1510455018

OVERALL DISCUSSION

From the analysis, it is deduced that there is an increase in port utilization when each and every model is used. Results have shown that the model that optimizes port utilization is King Abdullah's economic city port because it has been observed to have the lowest mean absolute percentage error of 0.037719389. In addition, the results further indicate that there is a need to increase the utilization of the TEU capacity in the port in order to optimize the profit margin. However, the need to comply with the 80% standards is not

limited to ensuring that the requirement is met, but also comes with an added advantage. At present, KAP is at 37%, a position that undermines its profitability because, ideally, an 80 per cent capacity increase the profit margin due to the scale of trade [15]. Moussa [15] further pointed out that there are minimal additional costs in the handling of TEUs within the scope of the regulation. The need to increase the profit margin therefore calls for the support of the measure put in place by KAP's project management team to be followed by an increase in the use of containers as well as an increase in the utilization capacity of the current 37% to 80%. Furthermore, there is a need to improve coordination within the King Abdullah port in order to succeed in increased utilization [15]. Similarly, the management may decide to develop policies that govern the activities undertaken within the port, such as the definition of the acceptable utilization capacity of the container to be handled in the port.

CONCLUSION

This work was done to analyze the exploitation of the Free Zone in order to promote the commercial interest in the KAP. Key results have shown that there is an increase in port usage when each and every model is used. Results have demonstrated that the model that optimizes port utilization is King Abdullah's economic city port, as it has been found to have the lowest mean absolute percentage error. For future work, the authors recommend to develop mathematics model that can be able to forecast the TEU capacity of the port that maximize the profit.

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