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Realization of Vessel Productivity Enhancement via Comparative Analysis of Liner Services: A case of Qasim International Container Terminal (QICT) DP World, Karachi

Muhammad Kashif Afzal*, Hafiz Shahrukh Zohaib**

Abstract

The landscape of the shipping industry is constantly evolving. The key aspect point among numerous issues is the efficiency of container loading and offloading on the quayside. This research aims to analyze the performance of Qasim International Container Terminal (QICT) DP World Karachi, Pakistan via Key Performance Indicators (KPIs) evaluation, based on data gathered fqictfrom QICT, and to find the critical factors affecting the overall productivity of QICT. Comparative analysis of liner services of Maersk between Mawingu (MWG) Express and Jade Express was performed via KPI's data collection from the Operation Department of QICT. This research concludes that vessel Productivity is reliant upon several factors. The most significant among all is the competence of the operator, number of quay cranes utilized at the terminal, number of transfer vehicles, berth allocation, and yard utilization. The study recommends to the terminal regarding optimum number of crane allocation and appropriate yard management to enhance the productivity of the JADE liner service via proactive maintenance of the ship-to-shore cranes.

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1. INTRODUCTION

Containerization has led to the evolution of the shipping industry, resultantly, the size and capacity of the ships increased as shipping companies get additional benefits on the economies of scale[1].

Figure 1. Shows the present leanings in the shipping industry that pressurizes ports to increase productivity. (Source: UNCTAD 2017)

The growing size of container vessels continually injecting altering port productivity and intensifies competition among container terminals globally, both on a national and international scale[2]. However, financial pointers are concerned with costs expended and profits generated by a terminal through its operations. Operational factors that influence these indicators include metrices: the number of containers moves per hour by quay cranes, container dwell time, the average turnaround time of vessels, and the productivity of operators.[3]. An improved understanding of variables that institute delays of cargo

1 Meersman, Hilde, Eddy Van de Voorde, and Thierry Vanelslander. "Nothing remains the same! Port competition revisited." In Smart Transport Networks. Edward Elgar Publishing, 2013.

2 Da Cruz, Maria Rosa Pires, João J. Ferreira, and Susana Garrido Azevedo. "A static and dynamic strategic portfolio analysis: The positioning of Iberian seaports." South African Journal of Business Management 43, no. 1 (2012): 33-43.

3 Chung, K.C. Port performance indicators (No. 81609, pp. 1-5). The World Bank. (1993).

in container terminals and directing major issues are important to enhance the productivity of a container terminal[4].

Qasim International Container Terminal (QICT), managed by DP World Dubai has an isolated truck holding area for all import and export vehicles to accelerate fast truck turnaround. To build the QICT, 03 existing multipurpose berths of six hundred meters in length were transformed into 02 berths container terminals for USD 100 million. Operational since August 1997, the terminal spans 240,000 square meters. Designed to handle 0.6 million twenty equivalent units (TEUs) per year, the terminal can handle vessels up to three hundred and five meters in length (DP World, n.d)[5].

Figure 2. Qasim International Container Terminal (QICT) (Source: DP World, "Qasim International Container Terminal (QICT)," https://www.dpworld.com/en/karachi (Accessed [10-10-2023])

A serious concern of port logistics at container terminal is the dwell time as the reduced dwell time enables the port to perform more efficient. However, non-reliable dwell time is leads to time and efficiency problems. Terminal operators face challenges in optimizing

[4] Al-Eraqi, Ahmed Salem, Carlos Pestana Barros, Adli Mustaffa, and Ahamad Tajudin Khader. "Evaluating the location efficiency of Arabian and African seaports using data envelopment analysis (DEA)." (2007).

[5] DP World. "About DP World Karachi." Accessed [10/10/2023]. https://www.dpworld.com/en/karachi/about-us/about-dpw-karachi.

their operations, particularly in minimizing unproductive and costly container handling within the terminal[6]. Despite all the achievements in improving container terminal performance in terms of equipment and container stacking systems (CSS), terminal operators are still facing several challenges such as the Loading and unloading process at Container Terminals and Container Yards that cause bottlenecks in container utilization[7]. The scientific planning and scheduling in process of loading, unloading, collecting, and carrying container operations directly affect the production efficiency of the container terminal. This implies a need for port authorities to implement more robust strategies to maintain efficient and competitive port services[8]. The following flowchart depicts the service process flow chart of ship loading / unloading system:

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6 Abdullaha, M. R., and J. R. Wira. "Enhancing Port Performance Using Productivity Modelling." (2012).

7 Mazloumi, Mehdi, and Edwin van Hassel. "Improvement of Container Terminal Productivity with Knowledge about Future Transport Modes: A Theoretical Agent-Based Modelling Approach." Sustainability 13, no. 17 (2021): 9702.

8 Zohaib, H. S., & Zaidi, S. S. Z. (2022). Antecedents of Maritime Supply Chain Resilience Affecting Supply Chain Performance–An Empirical Study Based on Pharmaceutical Industry. GMJACS, 12(2), 82-103.

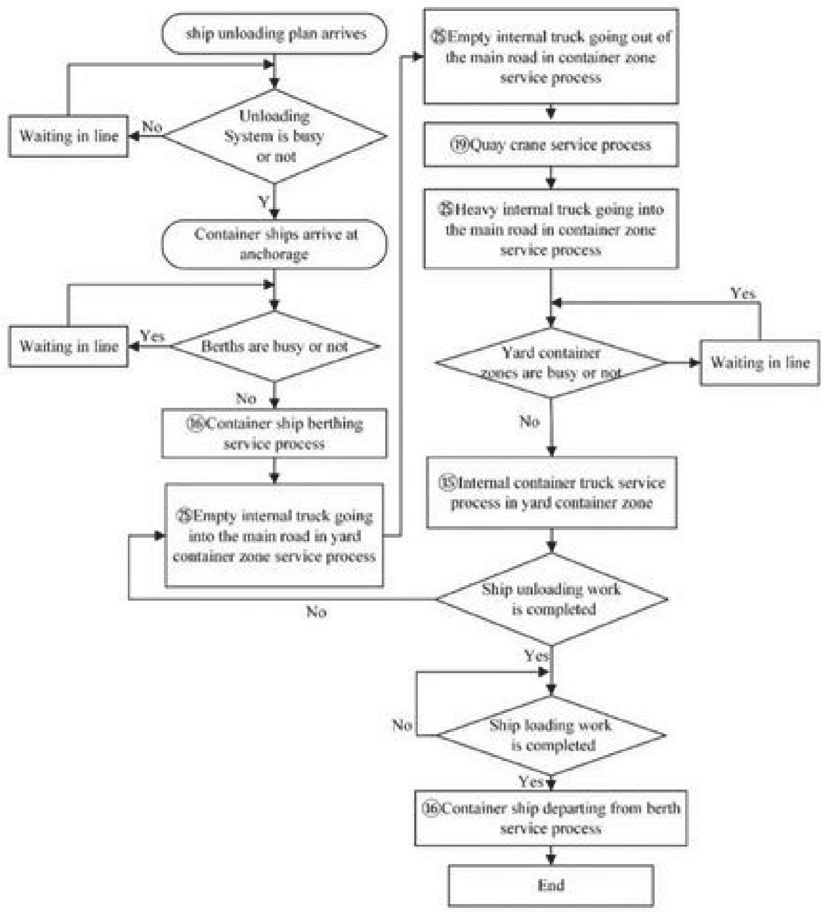

Figure *3.* Service process flow chart of ship loading / unloading system (source : https://www.researchgate.net/figure/Service-process-flow-chart-of-ship-loading-unloading-system_fig4_356390330)

The potential vessel productivity is much higher than the actual resulting productivity of one service MWG is consistently low and there are numerous causes behind it. Therefore, DP World Karachi would like to increase its vessel productivity for MWG Service by making key decisions on controllable variables, considering the possibility of any process improvement associated with the steps involved, and performing gap analysis with another service with consistently higher GMPH. Therefore, it leads to the following research questions:

RQ 1. What are the factors that affect efficient container handling operations?

RQ 2. Are determined factors applicable to QICT?

RQ3: What are the potential causes that are currently limiting the productivity of MWG service?

RQ 3. Can improvements in the efficiency of container handling operations be made at QICT?

RQ 4. If improvements are made, can these achieve a increased GMPH target on the MWG service?

The objective of this research is to identify and mathematically realize the gaps in the operability of QICT and further suggest ways to enhance/improve decision-making on controllable KPIs for enhancing productivity. Moreover, the study is focused on observing the present status of Qasim International Container Terminal operations and ship handling operations at QICT. Considering that relevant to Pakistan, maritime sector literature is scarce[9]. This area needs attention because terminal and ship handling operations are significant for terminal operations. As the containerized trade volume is increasing annually, the same traditional method of operating is not compatible with increasing and variating terminal demands. This impedes the true potential of productivity of the terminal. The customary method utilized to gauge the productivity of a container terminal employs the number of containers moves hourly handled by a quay crane or STS crane[10]. The productivity measures for the research include:

1) The total time of a vessel at berth
2) Service, TEUs per hectare
3) Quay cranes productivity
4) Operator productivity
5) The number of vessels visiting under both services at QICT.

[9] Ahmed, Azhar. "Role of Maritime Strategy in National Security-a case study of Gawadar." PhD diss., National Defence University, Islamabad, 2014.

[10] Review of Maritime Transport 2013 - UNCTAD

Terminal productivity is evaluated from different perceptions such as efficacy, comparative and mechanical productivity, and cost-effectiveness against the optimal throughput[11]. One method to measure the productivity of major container terminals is by examining the relationship between the percentage of utilization and optimal throughput of a single variable. However, it disregards the exchange and association between the factors of productivity[12]. Moreover, specifies the correlation of high quay output with the increased number of ships awaiting berth, which causes the bottleneck.

The figure below exhibits the container terminal and the variability of operability, which has a significant impact on the productivity and efficiency of a container terminal. The berths handle the arrival of ships to the terminal, including pilotage services, tug assistance on request of the ships, and mooring activities. Cargo is transshipped from the terminal to the ship and from the ship to the terminal in the apron area. The temporary storage of cargo in terminal stacking areas in anticipation of further transportation. Connection to the hinterland is by road or rail (i.e., gated).

[11] Erkyehun, Eyerusalem. "Determinant of Dry port operational performance of Ethiopian shipping and logistic service enterprise (eslse): the case Modjo And kality dry port branchs." PHD diss., St. Mary's university, 2021.

[12] Alhameedi, Mohamed Ebrahim AS, Abud Jamal Said, and Tri Wahyunita Mudjiono. "Performance evaluation and solutions for port congestion focused on the container terminal: a case study of Khalifa bin Salman Port (KBSP) Kingdom of Bahrain." (2018).

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2. LITERATURE REVIEW

Figure 4. A Schematic Container terminal layout (From Process Mining for port container terminals: The state of the art and issues, 2018)

Productivity is defined as the efficient use of resources (inputs) in the production of goods and/or services (output)[13]. However, productivity of container terminals may be measured in two different ways in the shipping industry. Vessel operations are the first category, which includes the loading and discharge of containers onto and from vessels. Container transfer between outside vehicles during receiving and delivery activities is the other one[14].

Port performance measurement is a crucial input for nationally and internationally port planning and operations in the current business market. It is also a strong management tool for port operators. It has been stated that earlier, many methods of evaluating the operation of

[13] Sumanth, David J. "Productivity Engineering and Management: Productivity Measurement, Eveluation, Planning, and Improvement in Manufacturing and Service Organizations." (1984).

[14] Kim, Kap Hwan, Keung Mo Lee, and Hark Hwang. "Sequencing delivery and receiving operations for yard cranes in port container terminals." International Journal of Production Economics 84, no. 3 (2003): 283-292.

ports have included estimating cargo-handling productivity at berth[15]. The cargo transfer across a quay between ship and shore essentially determines the vessel's productivity and is essential to its competitive position because a container shipping line is one of a container port's most important clients. The gantry crane is the most crucial piece of equipment in the entire process (the quay crane transfer operation)[16]. It has been argued that the container terminal's production relies on the optimum use of labor, land, and equipment. Therefore, terminal production is measured through quantifying efficiency in the utilization of these three resources[17].

2.1 Vessel Productivity

Vessel Productivity or productivity, in general, is an overview of the number and quality of work performed while taking resource usage into account. Productivity (P) is defined as the average of the gross moves per hour (GMPH) for each call recorded last year. Gross moves per hour for a single vessel call is defined as the total container moves (load, offload, and repositioning) divided by the number of hours for which the vessel is at berth. However, productivity is defined as the efficient use of resources (inputs) in the production of goods and/or services (output)[18]. While it has been stated that the productivity of container terminals may be measured in two different ways in the shipping industry. Vessel operations are the first category, which includes the loading and discharge of containers onto and from vessels. Container transfer between outside vehicles during receiving

[15] Helen B. Bendall and A. F. Stent, "On Measuring Cargo Handling Productivity," Maritime Policy & Management 14, no. 4 (1987): 337–43, https://doi.org/10.1080/03088838700000046.

[16] Bendall, Helen B., and A. F. Stent. "On measuring cargo handling productivity." Maritime Policy and Management 14, no. 4 (1987): 337-343.

[17] Dowd, Thomas J., and Thomas M. Leschine. "Container terminal productivity: a perspective." Maritime Policy & Management 17, no. 2 (1990): 107-112.

[18] Sumanth, David J. "Productivity Engineering and Management: Productivity Measurement, Evaluation, Planning, and Improvement in Manufacturing and Service Organizations." (1984).

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Many factors may have an impact on the productivity of the vessel but there are five factors or variables that are major or rather mandatory to determine the vessel productivity and the variables are:

1. Berth/Wharf#
2. Yard Utilization
3. Number of Cranes Used
4. Vessel Type
5. STS Operators' Performance

3. METHODOLOGY

The research was conducted in an applied approach where a quantitative method is used for analyzing data on key variables driving the productivity of a container terminal at QICT. The site of research

[19] Kim, Kap Hwan, Keung Mo Lee, and Hark Hwang. "Sequencing delivery and receiving operations for yard cranes in port container terminals." International Journal of Production Economics 84, no. 3 (2003): 283-292.

[20] Bendall, Helen B., and A. F. Stent. "On measuring cargo handling productivity." Maritime Policy and Management 14, no. 4 (1987): 337-343.

[21] ibid

[22] Dowd, Thomas J., and Thomas M. Leschine. "Container terminal productivity: a perspective." Maritime Policy & Management 17, no. 2 (1990): 107-112.

was Qasim International Container Terminal (QICT). This site was selected due to its huge volume of containerized trade and the significance of the multi-purpose container terminal. The research methodology employed in this study aimed to comprehensively evaluate the productivity of Qasim International Container Terminal (QICT) in the maritime sector. To achieve this objective, a multi-faceted approach was utilized. The initial step involved the collection of extensive data on terminal operations, vessel movements, and various performance indicators over a one-year period. The data was collected from the operations department of the QICT.

The data formed the foundation for quantitative analysis and the identification of key patterns and trends. Subsequently, detailed statistical analyses and comparative assessments were conducted to gauge the efficiency of QICT in different aspects, including berth allocation, crane performance, and service productivity. Specifically, parameters under investigation were productivity, berth allocation, yard utilization, number of cranes utilized, and operator performance data were collected to comparatively analyze the productivity of both of the services. Moreover, data accessibility was limited as the operations department provided only a restricted data set due to confidentiality concerns.

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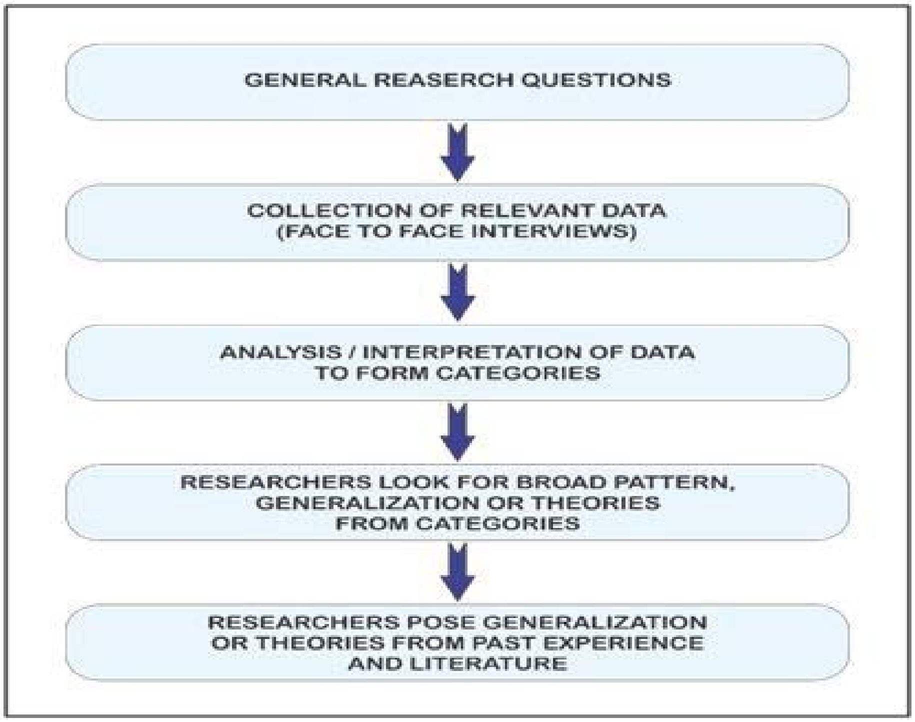


Figure 5. Phase I general research process[23].

4. DATA ANALYSIS

Most importantly used KPIs include Vessel traffic, and the number of vessels entering/ leaving a container terminal facility over a period which also determines the local effectiveness of a container terminal. An important element in determining the total number of containers (TEUs) managed within a specific period is what we refer to as productivity measurement which assesses the efficiency and effectiveness of various processes involved in container handling at ports or terminals. The assessment of the vessel productivity of a container terminal principally quay cranes utilized in containers handling to/from a vessel is termed operative productivity[24].

[23] Bell, Emma, and Alan Bryman. "The ethics of management research: an exploratory content analysis." British journal of management 18, no. 1 (2007): 63-77. Creswell, John W. "Mapping the field of mixed methods research." Journal of mixed methods research 3, no. 2 (2009): 95-108.

[24] Chen, Longbiao, Daqing Zhang, Xiaojuan Ma, Leye Wang, Shijian Li, Zhaohui Wu, and Gang Pan. "Container port performance measurement and comparison leveraging ship GPS

4.1 Berth / Wharf Number

The primary performance indicators of a container port are considered berth allocation and vessel storage planning[25]. One of the main planning issues for container port operations is the Berth Allocation Problem. Every vessel anticipated to be served within a certain perspective of planning is allotted a berthing spot and a time of berthing[26].

It has been realized that the MWG service is having greater productivity when the vessel is being berthed at Wharf number 07 than at wharf number 05 and 06. This is due to the distance of the stacking yard designated for MWG service being much nearer from wharf number 07 as compared to that of wharf number 05 and 06. During the berth planning, it is recommended that the MWG service should be allocated wharf number 07 if available to enhance the productivity of the MWG service

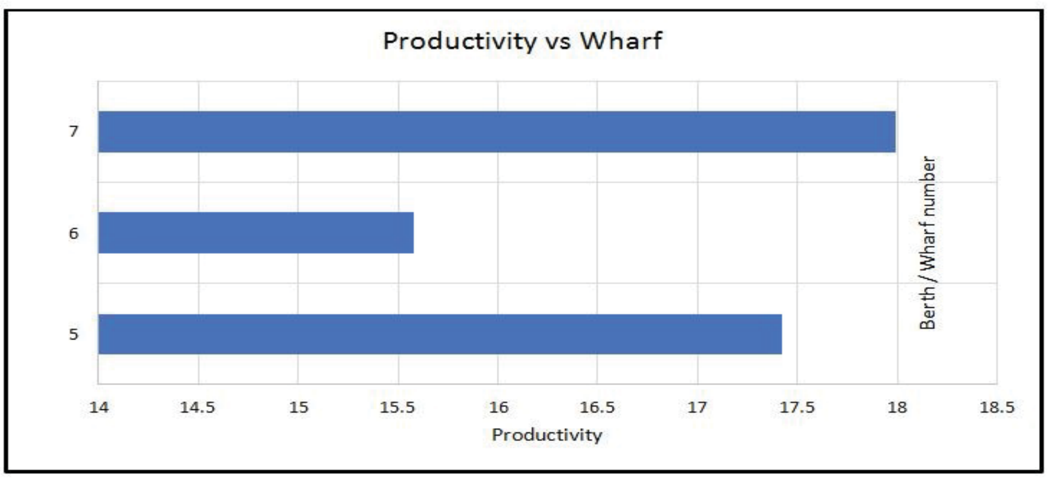


Figure 6. Shows productivity concerning the allocated berth/wharf number.

traces and maritime open data." IEEE Transactions on Intelligent Transportation Systems 17, no. 5 (2015): 1227-1242.

[25] Vis, Iris FA, and Roel G. van Anholt. "Performance analysis of berth configurations at container terminals." OR spectrum 32, no. 3 (2010): 453-476.

[26] Steenken, Dirk, Stefan Voß, and Robert Stahlbock. "Container terminal operation and operations research-a classification and literature review." OR spectrum 26, no. 1 (2004): 3-49.

4.2 Yard Utilization

It has been claimed that the terminal's vessel productivity is also affected by the workload of transport means within the yard. It could be determined by the distance between the areas for import and export containers[27]. For a vessel near these yard areas, a preferred berthing site is typically stated. The horizontal transport's load rises if the actual berthing position chosen differs from the desired position. Increasing ITVs usage can help to mitigate this effect to some extent.

Below mentioned data shows the relationship between productivity and yard utilization during the vessel operations (From QICT records)

R-Square (coefficient of Determination = 0.153)

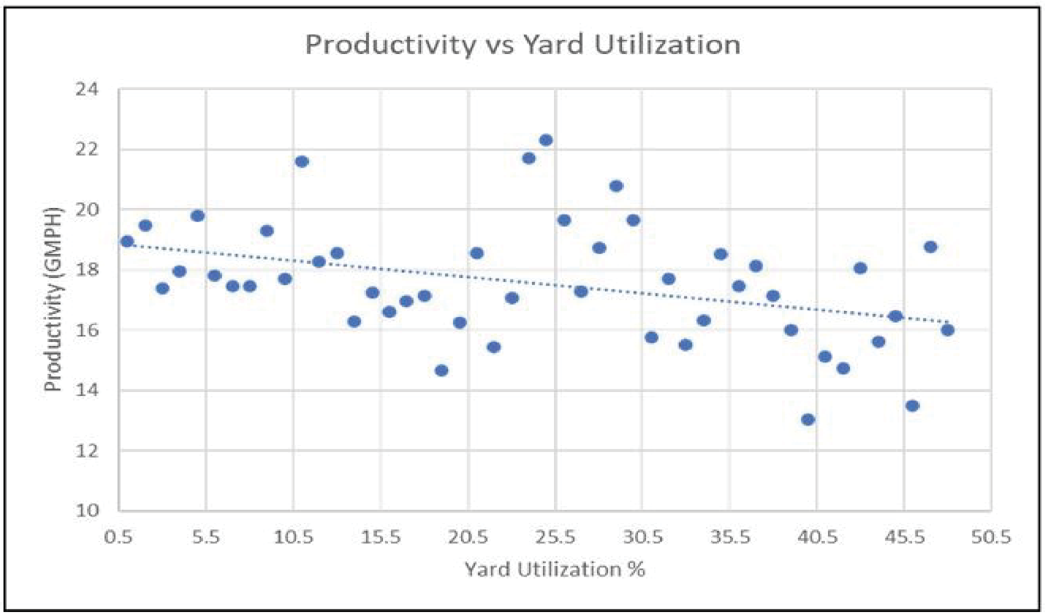


Figure 7. *A relationship between Productivity (GMPH) and Yard Utilization in the progress of vessel operations.*

The Yard utilization graph interpretations that the increases in yard utilization led to a decrease in overall vessel productivity. The berth/wharf allocated to the vessel affects the yard utilization in such a

[27] Meisel, Frank, and Christian Bierwirth. "Heuristics for the integration of crane productivity in the berth allocation problem." Transportation Research Part E: Logistics and Transportation Review 45, no. 1 (2009): 196-209.

manner that if the stacking yard of that service is on more distance from the berth/wharf then it will involve more yard utilization and lead to lower productivity. Therefore, the vessel must be assigned a berth/wharf that is at a short distance from the stacking area of that respective service to have enhanced productivity.

4.3 Number of Cranes Used

At a container terminal, quay space and quay cranes (QCs) are valuable components. Generally, the Quay Crane Assignment Problem (QCAP) emerges when multiple vessels moor at the quay at just about the same timeframe. The minimal number (agreed upon by the vessel operator and the operator of the Container Terminal) and the technically permissible maximum number are sometimes used to limit the number of QCs serving a vessel concurrently. The QC-to-Vessel assignment may alter as a vessel is handled.

Below mentioned data shows productivity to berth/wharf number of the vessels being berthed during the vessel operations (From QICT records)

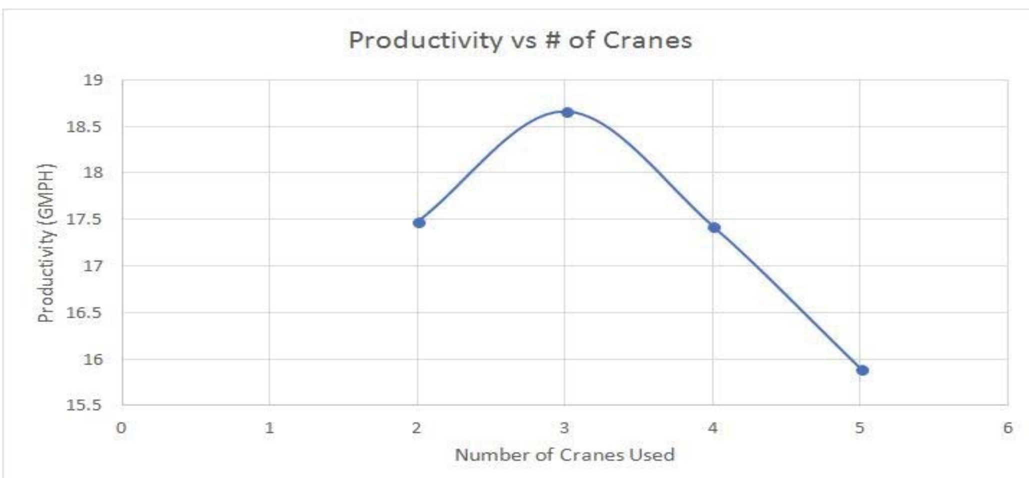


Figure 8. Relationship between Productivity & Number of Quay Cranes used during vessel operations at QICT.

The number of cranes used affects productivity in such a different manner than if there are a smaller number of cranes used then it will decrease productivity because of more time taken to complete the operation & a greater number of bays covered by a single crane. On the other hand, an increased no of cranes will also minimize productivity as it will cause congestion of ITVs in the Terminal. Modeling and simulation tools/systems must be introduced for optimization of the number of cranes used with respect to the vessel size. This system must be capable of aiding the terminal planners to use exactly those numbers of cranes for efficient operations according to the size of the vessel.

4.4 Vessel Type

The vessel's productivity is significantly affected by its structural design, especially when the placement of containers and superstructure obstructs crane operations during bay changes. When the superstructure is positioned at a higher altitude, it forces the crane to raise its boom, leading to delays, increased time consumption, and decreased overall productivity.

4.5 STS Operators' Performance

Container Terminal operators constantly put effort into saving time and focusing on restructuring loading and offloading procedures. Turnaround time is a crucial one and a large portion of the container terminal turnaround time depends on loading and offloading operations[28]. Enhancing container handling operations productivity is dependent largely on the STS crane operator's efficiency. The Crane operator's performance changes the efficiency of the whole container terminal. Productivity of a lift of a container for loading, offloading, or relocating purposes[29]

[28] Cao, Jin Xin, Der-Horng Lee, Jiang Hang Chen, and Qixin Shi. "The integrated yard truck and yard crane scheduling problem: Benders' decomposition-based methods." Transportation Research Part E: Logistics and Transportation Review 46, no. 3 (2010): 344-353.

29 Bojan Beškovnik, "Measuring and Increasing the Productivity Model on Maritime Container Terminals," Pomorstvo/Journal of Maritime Studies 22, no. 2 (2008)

Crane Operator Performance = Gross moves/ Total hours expanded

Operators should aim to minimize waiting times by optimizing crane allocation and intensities. Comprehensive operator training is essential to ensure all operators have the required skills to perform their tasks efficiently. Thus, container terminals should implement effective training programs to maximize operator productivity. *The data provided displays shift-wise productivity for each crane operator, determined by the number of moves and their total working hours during April 2022*

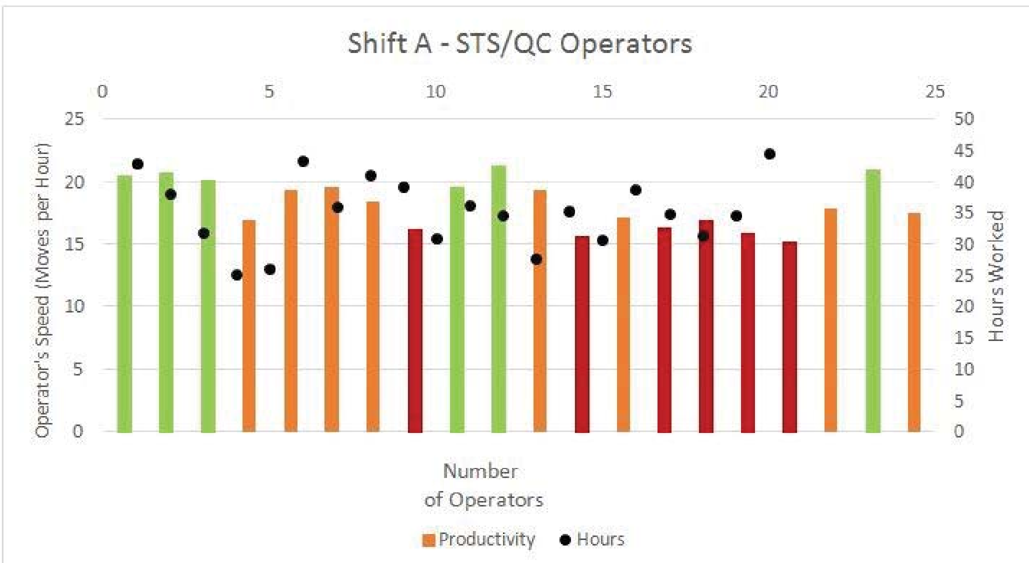


Figure 9. Shows the productivity of Shift 'A' STS Crane Operators in terms of moves per hour and total hours expanded for one month at QICT.

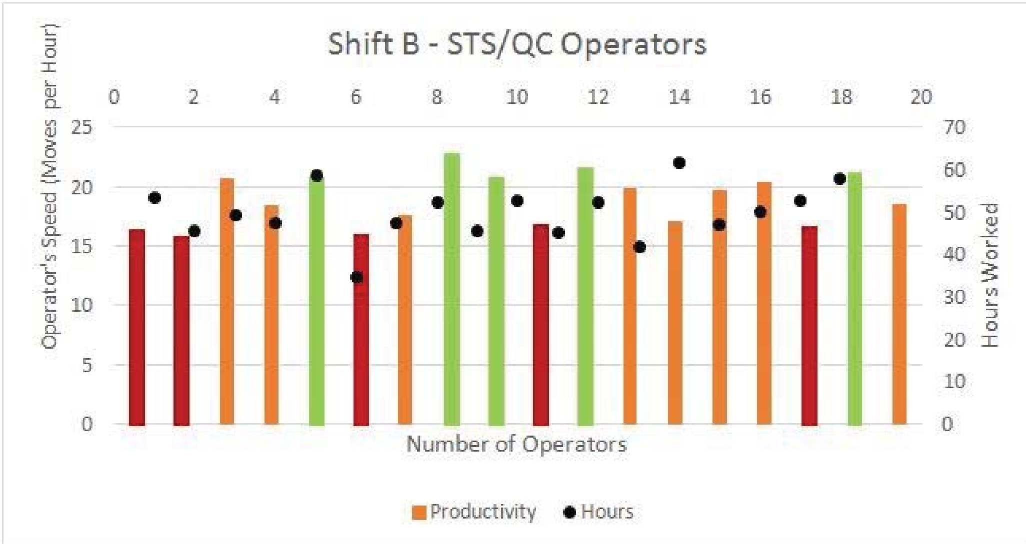


Figure 10. Shows the productivity of Shift 'B' STS Crane Operators in terms of moves per hour and total hours expanded for one month at QICT.

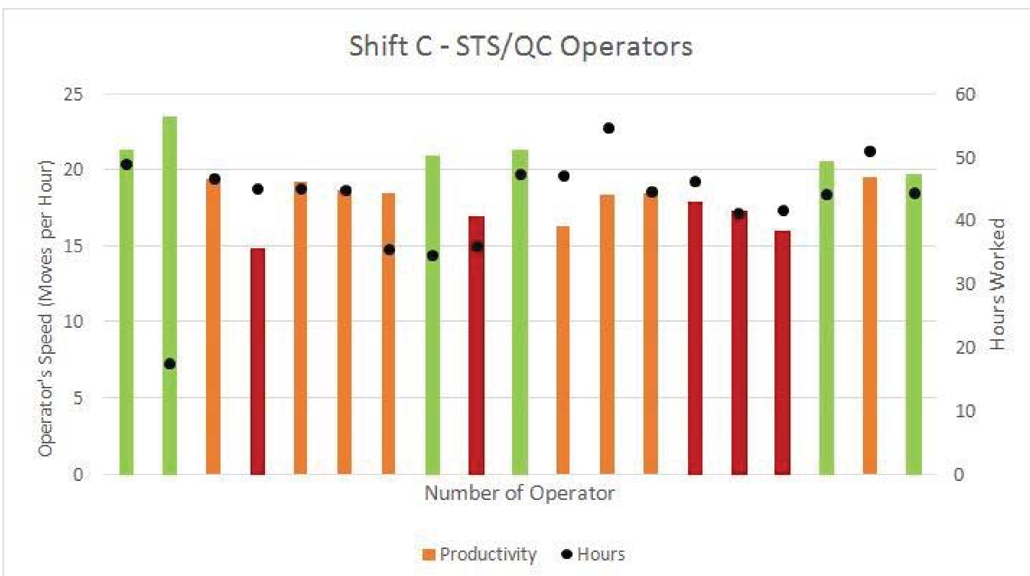


Figure 11. Shows the productivity of Shift 'C' STS Crane Operators in terms of moves per hour and total hours expanded for one month at QICT.

The provided figures demonstrate a range in productivity among 57 Crane Operators at QICT, varying from 14.87 to 23.46 Moves per hour. Operator 2's productivity is notably 58% higher than the lowest-performing Operator 4, indicating a significant skill gap. To address this gap, QICT management should consider incentivizing low-performing operators to improve and implement a training program using STS simulators. Ensuring transparency in operator rotation is vital to offer every operator an equal chance for improvement, ultimately enhancing overall productivity.

The data highlights the suboptimal usage of operators. Each operator's productivity varies significantly from the others. To enhance service productivity, it's necessary to optimize operator usage by shifting from random shift patterns to those aligned with the terminal's requirements.

5. COMPARATIVE ANALYSIS OF LINER SERVICES (MWG vs JADE)

The comparative analysis of MWG and JADE services of Maersk Line is done in terms of their Vessel Traffic, throughput, Gross Moves Per Hour (GMPH), and average vessel turnaround time. MWG (Mawingo) service touches the ports of Mombasa (Kenya), Salalah (Oman), Port Qasim (Pakistan), Mundra (India), Pipavav (India) and Jawaharlal Nehru (India).

5.1 VESSEL TRAFFIC

Vessel traffic data was acquired for the past fourteen months (Jan 21 – Feb 22). The figure below shows month-wise vessel traffic arriving at QICT.

vessel traffic records for MWG and JADE Services, detailing the number of arrivals and departures, along with the actual arrival and departure times at QICT. The data spans from January 2021 to February 2022

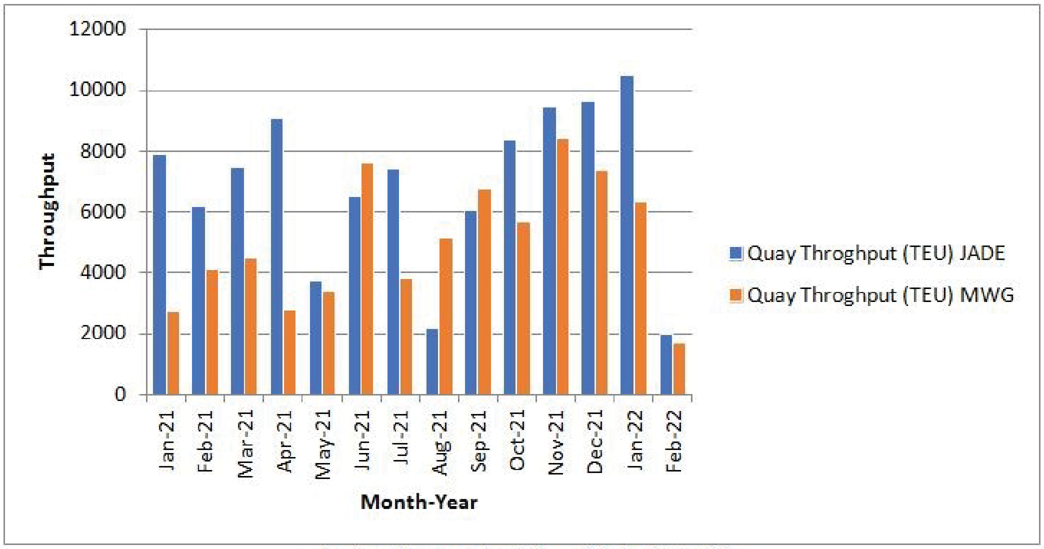
Figure 12. Vessel Traffic of JADE & MWG Services arriving at QICT (Jan 21 – Feb 22).

The data reveals that QICT had 48 vessels arrive for JADE Service and 49 for MWG Service. Notably, 5 vessels visited in July, October, and December 2021, marking the highest number of port calls for JADE Service. Similarly, for MWG Service, the highest number of vessels visiting was also 5 in June, September, and November 2021. On average, approximately 3.5 vessels visited per month for JADE Service, and 3.4 for MWG Service. This suggests a similar number of vessels visiting for each service. A comparative analysis of JADE and MWG services is crucial to identify the factors contributing to MWG's lower productivity compared to its capacity.

5.2 QICT THROUGHPUT (JAN 21 TO FEB 22)

Quay Throughput (TEUs) represents the quantity of TEUs moved over the quay wall for Mainliners, Feeders, and Barges, excluding Hatch covers, lashing bins, and convenience re-stows. Data on the throughput of JADE and MWG Services was gathered from Qasim International Container Terminal (QICT). The table below displays the combined throughput for both services. The lowest throughput for both services occurred in February 2022, attributed to fewer vessel visits at the container terminal. In contrast, the highest throughput for JADE Service was 10,515.75 TEUs in January 2022, and for MWG Service, it reached 9,474.25 TEUs in November 2021

Below mentioned data shows the QICT quay throughput of JADE & MWG Services during the period Jan 21 to Feb 22



during the period Jan 21 to Feb 22

Figure 13. Container Terminal Throughput of JADE & MWG Services.

Figure depicts the throughput trend from January 2021 to February 2022 for JADE and MWG Services. JADE Service generally maintained higher throughput compared to MWG Service, except for three months (June 2021, August 2021, and September 2021). In January 2021, the throughput of JADE Service was 7,908.25 TEUs, which was 191% higher than MWG Service's 2,717 TEUs. To enhance operational efficiency, it's suggested to classify liner services into A, B, and C categories based on their throughput, with first-class services receiving priority in terms of equipment availability and early berthing due to their significant contribution to QICT's revenue. Collaboration with MWG service agents is also recommended to address inconsistent throughput in this liner service.

5.3 GROSS MOVES PER HOUR (GMPH)

Gross Moves Per Hour (GMPH) indicates the number of containers moved by a crane and it is the customary measurement to calculate productivity for handling containers at container terminals[30].

the average gross moves per hour, calculated from loading, offloading moves, and crane hours for the JADE and MWG Services (from Jan 21 to Feb 22)

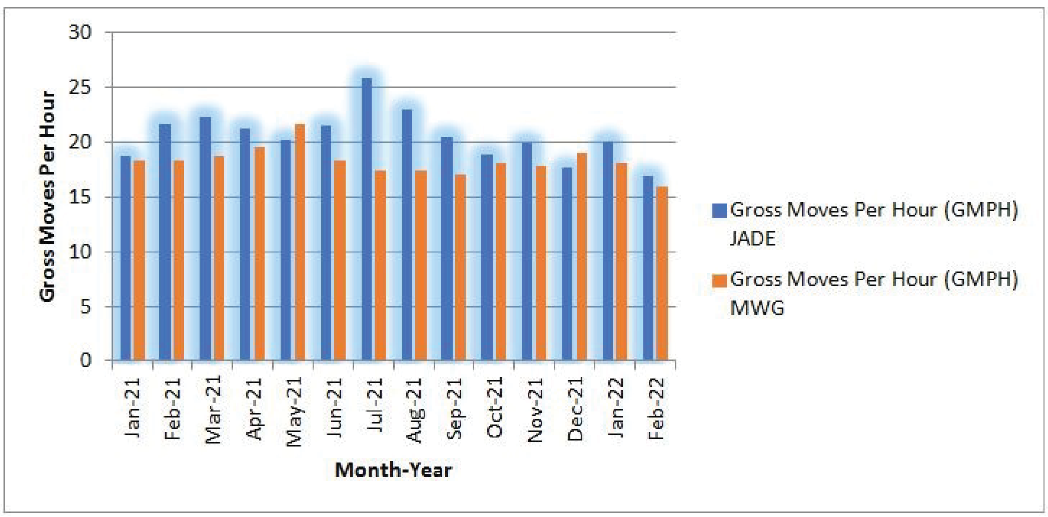


Figure 14. Shows Average Gross Moves Per Hour for the JADE & MWG Services (Jan 21 – Feb 22).

Gross Moves Per Hour for JADE Service at QICT varied from 16.93 to 25.86 and remained between 15.93 to 21.7 for MWG Service. It has been realized that the same quay crane operators and quay cranes were utilized for handling containers of both services, however, Gross Moves Per Hour for JADE Service has remained higher throughout the year than MWG Service except for May & Dec 21. The above graphical analysis indicates that the arrangement of containers on container terminal i.e., t the yard needs to be reviewed/ reorganized to achieve increased GMPH for MWG Service. Intense collaboration

[30] Global Port Pricing Comparator Study 2015. (n.d.). Ports Regulator of South Africa. https://portsregulator.org/global-port-pricing-comparator-study-2015/

is needed with MWG service's agent to show up their plans regarding port calls at QICT to have good productive results.

5.4 AVERAGE TURNAROUND TIME

Turnaround time is the complete time ship spends at a terminal from ATA (Actual Time of Arrival) until ATD (Actual Time of Departure)[31]. Usually, a vessel is not making money during her stay at the terminal but pays for the terminal services, therefore, shipping companies tend to limit the turnaround time as minimum as practicable. Pakistani ports have one of the highest port dues charges, therefore, vessels must be attended to with the greatest proficiency to minimize port stay leading to the omission of extra port dues.

Below mentioned data shows the average turnaround time of a vessel considering the total berth time for JADE & MWG Services from Jan 21 to Feb 22 (From QICT records)

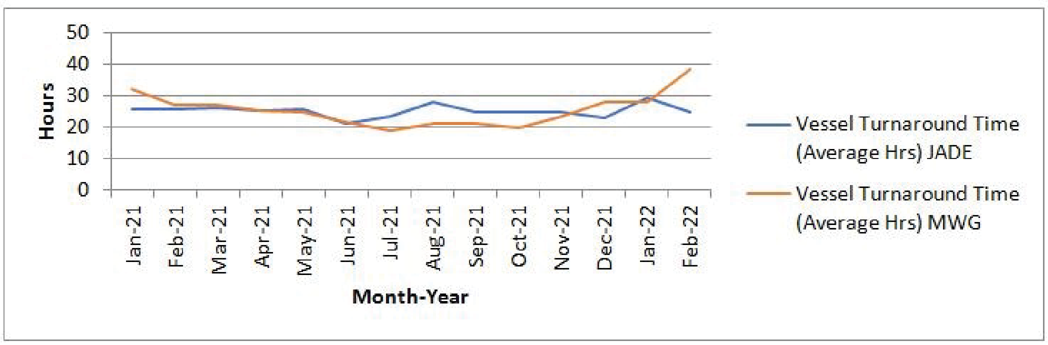


Figure 15. Demonstrates month-wise average turnaround time (in Hours) of JADE & MWG Services (Jan 21 – Feb 22).

Average turnaround times for JADE Service varied from 29.29 hours in January 2022 to 21.24 hours in June 2021. In contrast, MWG Service saw a range from 38.33 hours in February 2022 to 19.77 hours in October 2021. MWG Service displayed a steady decline in

[31] Sánchez, Ricardo J., Jan Hoffmann, Alejandro Micco, Georgina V. Pizzolitto, Martin Sgut, and Gordon Wilmsmeier. "Port efficiency and international trade: port efficiency as a determinant of maritime transport costs." Maritime economics & logistics 5, no. 2 (2003): 199-218.

turnaround times from 32.33 hours in January 2021 over six months until July 2021. In comparison, JADE Service started at 25.87 hours in January 2021 and remained steady for five months until May 2021.

JADE Service generally had a longer average turnaround time than MWG Service due to handling a larger volume of containers, necessitating extended vessel stays. However, opportunities for improvement exist, including reducing equipment and quay crane failures that can prolong vessel stays. Operational enhancements such as increasing the number of cranes, minimizing shift change delays, and improving crane operator efficiency can help achieve this. UNCTAD suggests that the average vessel turnaround time is 33 hours, with most vessels aiming to stay within port limits for less than a day due to the 24-hour rate for port dues.

5.5 SHIP TO SHORE (STS) CRANES PRODUCTIVITY DURING MAR 22

An STS crane is purposefully designed for handling container Ships. These days, the biggest STS cranes can handle more than 120 tons and are capable of outreaching more than 70 meters and a lifting elevation of up to 50 meters [32]. Numerous STS cranes handle containers concurrently on a single ship. Operating side by side requires enough space to function freely. As the STS cranes are in direct contact with the ships, therefore, the productivity of ship-to-shore actions is a very precarious phase at any container terminal. While analyzing the productivity of STS crane operations, the most important standard moves per hour (mph). It denotes the number of containers or TEUs relocated per hour. The productivity of an STS crane is gauged by the said method[33].

[32] S. (n.d.). STS Gantry Crane. Https://Www.Weihuagantrycrane.Com/Product/STS-Gantry-Crane.Html. https://www.weihuagantrycrane.com/product/STS-Gantry-Crane.html

[33] Koivula, Jarno. "Modelling and simulation of ship-to-shore operations for productivity analysis." Master's thesis, 2019.

the productivity of every STS crane in terms of moves per hour during the day & night shifts

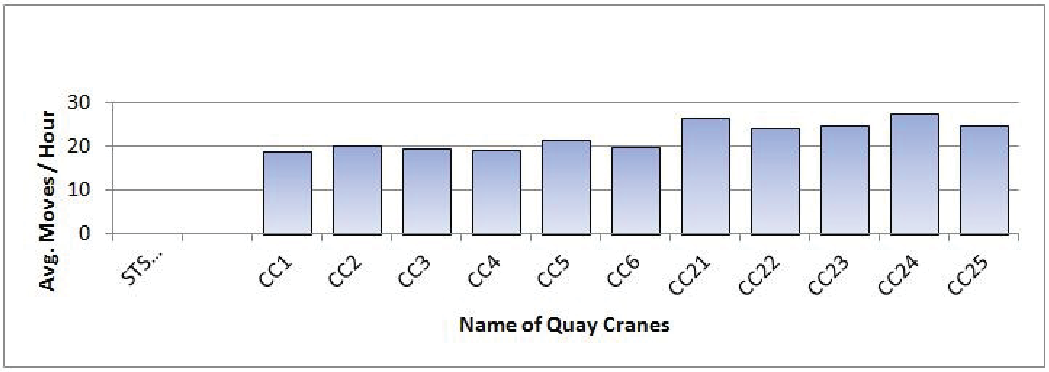


Figure 16. Shows the average moves of STS cranes per hour during Mar 22.

QICT operates 11 STS Cranes, with varying performance in March 2022. STS Crane CC24 demonstrated the highest productivity with 27.46 moves per hour, while CC1 performed at 18.80 moves per hour, the lowest among all. The older STS Cranes (CC1 to CC6) displayed lower productivity due to machinery failures and wear and tear. To improve performance, proactive maintenance is necessary to prevent sudden breakdowns. The engineering team should analyze patterns of breakdowns and failures. Therefore, increasing resource allocation to reduce failures in low-performing STS Cranes is essential for enhancing overall productivity at QICT.

6.1 DISCUSSION AND CONCLUSION

Qasim International Container Terminal (QICT) intends to offer supreme services and accommodates all shipping liners. The QICT is situated far away from the crowded city of Karachi, thus yielding a faster turnaround of the import and export freights. An analysis of the QICT productivity was undertaken with results. Now, this section is aimed at drawing substantial deductions and recommendations from the study.

Allocation of berth to a vessel is always a challenging task. As the actual time of arrival of vessels is not constant and always dependent on mechanical operational machinery and most importantly suitability of weather at sea. Also, when there are multiple vessels awaiting berth then the decision becomes more difficult. As QICT is handling more than 50 percent of the imports/ exports of Pakistan, therefore, a more efficient berth planning is required to increase the berth occupancy rate up to the maximum level possible to increase the productivity of the container terminal. An effective berth planning is also mandatory on occasion when a bigger vessel arrives after already awaiting a relatively smaller vessel in the harbor for productivity purposes. The objective of the research was to evaluate the efficiency of QICT to increase the productivity of the terminal, conduct analyses of the Key Performance Indicators (KPIs), and the comparison of MWG & JADE Services of the Maersk line. The research ascertains KPIs and their significance in the evaluation of the productivity of the terminal. Every month 3.5 (~4) vessels visited for JADE Service and for MWG Service it remained 3.4 (~4). An approximately equal number of vessels visited the terminal for both Services. It is pertinent to mention that the same quay crane operators and quay cranes were employed for handling containers of both services, conversely, Gross Moves Per Hour for JADE Service has persisted greater throughout the year than MWG Service except during the months of May & Dec 21.

There is a possibility of improving the productivity of the container terminal by ensuring the effective dispersal of resources. Generally, the average turnaround time of JADE Service continued to remain higher than MWG Service due to more container moves requiring a prolonged stay of vessels at the terminal. Moves of STS crane CC24 persisted highest i.e., 27.46 per hour which is the maximum of all STS Cranes available at QICT whereas average moves of STS Crane CC1 were recorded lowest i.e., 18.80 moves per hour. The productivity of operator 4 remained 58 % more than the lowest performing operator 2 additionally, the study found that operative productivity is affected by external elements which are out of control of QICT management such as weather interruptions and tidal effects. Port Qasim is a multi-purpose port with fishermen, ferry, automotive, containers, and liquid bulk freight terminals.

The study has encountered certain limitations, primarily stemming from constraints such as a limited amount of data spanning one year and concerns regarding dataset confidentiality posed by the data providers. A comparison was performed between the two liner services of Maersk Line i.e., MWG and JADE services. Literature is scarce for Pakistan's maritime sector which made it difficult to conduct the regional literature review. The conclusions of the research are based on data obtained from the QICT. The data obtained is limited, therefore it restricts to facilitate of the use of other Key Performance Indicators (KPIs).

The Research contributes to the productivity enhancement of MWG Service and the vessel productivity at QICT. The variables affecting the vessel productivity at a container terminal (CT) under analysis conclude as follows:

- Berth/Wharf number vs Productivity graph in Figure 6 illustrated that number 07 wharf/berth is the most productive one for MWG service during the port calls done by the container vessels of the service.
- This is due to the distance of the stacking yard designated for MWG service being much nearer from wharf number 07 as compared to that of wharf number 05 and 06.
- Yard utilization drives vessel productivity in such a manner that (in Figure 7) it was interpreted as an inversely proportional relationship between vessel productivity and yard utilization.
- Productivity relative to the Number of Quay cranes used (Figure 8) determined that less or greater number of quay cranes used causes a reduction in vessel productivity while the effective number of cranes used makes the vessel operation more productive. a higher quantity of cranes can lead to reduced productivity due to increased congestion of ITVs (Internal Transport Vehicles) within the terminal.
- Vessel type concerning its construction because of the location of accommodation and superstructures as a hurdle also affects the productivity during vessel operations.

- Graphs under Figures 9, 10, and 11 showed that some STS/QC operators are performing below average or on average and some operators are up to the mark.

The comparative analysis between the liner services of MWG and JADE is performed for the vessel productivity enhancement of MWG service at QICT. Both the services were under the vessel operatorship of Maersk Line. Comparing the vessel traffic of both the services the results showed that there is an approximately equal number of vessels calling QICT every month.

6.2 RECOMMENDATIONS

From the conclusions drawn in this study, the following specific recommendations are made:

6.2.1 Enhance Berth Planning Efficiency:

The variability in vessel arrival times and the challenges posed by multiple vessels awaiting berth demand an emphasis on more efficient berth planning. Develop sophisticated algorithms and real-time monitoring systems to optimize berth allocation, taking into account weather conditions and vessel schedules. However, Berth 7, as highlighted, is the most productive berth for MWG Service. This is likely due to its proximity to the designated stacking yard for MWG Service. Berth 7's efficiency may also be influenced by factors such as quay crane availability and yard access. To optimize the utilization of Berth 7, consider the following:

- **Dynamic Allocation**: Implement a dynamic berth allocation strategy that considers real-time factors like vessel schedules, weather conditions, and congestion levels.

- **Efficient Yard Management**: Coordinate closely with the yard management team to streamline container movements to and from Berth

6.2.2 Optimal Number of Cranes for Jade Service:

Determining the optimal crane count for Jade Service is contingent on several key factors. These include aligning crane numbers with demand and congestion levels within the terminal, establishing contingency plans to address maintenance and downtime, ensuring operational flexibility to adapt to fluctuations in demand, all of which collectively contribute to achieving an efficient and productive crane deployment strategy.

6.2.3 Enhance STS Crane Productivity Through Proactive Maintenance

A dedicated focus on proactive maintenance for STS cranes is vital. The low productivity observed in CC1 to CC6 cranes is primarily attributed to machinery failures and fair wear & tear. By allocating additional resources to preemptive maintenance, QICT can effectively mitigate these issues, ensuring uninterrupted operations and elevating overall productivity.

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