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A Regression Model of Dry Bulk Carriers' Loading Time

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Abstract: Although optimization of Vessel Turnaround Time (VTT) is a well-known research problem and its importance has long been understood, research on dry bulk carriers VTT has no priority in the available literature. It is one of the initial motives of the author to write this paper. After a general theoretical introduction, this paper presents research on dry bulk carriers' loading time, as a component with the dominant share in the total VTT. Through the research, a mathematical model of interdependencies between dry bulk carrier`s loading time and selected independent variables is defined using a multiple linear regression model. Results of statistical significance tests confirmed that the best-fit regression model is the one which adequately describes the correlation between the dry bulk carrier`s loading time and the following independent variables: cargo quantity (loaded), number of used cranes per vessel and loading process interruptions. The presented results establish important bases for the author's further research in this field as well as reliable planning bases for cargo handling management processes at dry bulk cargo terminals where cargo loading/unloading to/from vessels is realized by gantry cranes and/or mobile harbour cranes.

Keywords: Dry bulk carrier, Vessel Turnaround Time, loading time, regression model

1. Introduction

Seaports have critical importance for the global supply chain [1-3]. In reference [4], an evaluation of port importance is done based on four aspects: port resource ownership, control management, comprehensive services, and innovation-driven aspects. At the same time, seaports constitute an important economic activity, having a significant impact on economic activities in the belonging country and their wider hinterland and bringing different benefits [5-9]. Reference [10] brings a detailed review of additional literature regarding the valuation of the economic effects of seaports.

The importance of the ports is researched based on a model of the interrelation between ports and shipping and their socio-economic environment.

Port efficiency belongs to the group of three basic components of port performance, together with two others: effectiveness and resilience. The most frequently used indicators of terminal/port efficiency are [11]: berth occupancy, revenue per ton of cargo, capital equipment expenditure per ton of cargo, Vessel Turnaround Time (VTT), etc. Port efficiency could be considered as one of the key drivers of port competitiveness which has a significant role in boosting regional development [12].

VTT can be defined as the total time that a vessel spends at a port from its arrival to departure [13]. Optimizing VTT is a well-known research problem [14]. Its importance has long been understood. Reference [15] states that the essence of profitable ship operations was summed up almost 140 years ago.

VTT was examined by numerous relevant authors. Reference [16] demonstrates that double cycling can reduce ship turn-around time through this efficiency improvement. Reference [17] presents precise turnaround time data for a sample of general cargo ships and uses linear regression to explore the relationships. Reference [18] emphasizes that proper management of VTT could result in major cost reductions and improvement in the service. Authors of reference [19] pointed out the importance of continuous measuring of VTT in a port. The research results shown in reference [20] confirm that there are several factors to be considered in developing a port for faster VTT: economic factors, technical factors, operational/administrative factors, and other determinants including transport, handling and storage. Through the conducted research, reference [21] finds that the effects of VTT on vessel calls to ports are port-specific. Reference [22] investigates the quantitative effect of VTT on port performances. Reference [23] deals with the influence of the channel schedule on VTT. Research results given in reference [24] show that there is a significant relationship between port infrastructure and VTT. In reference [25] as a research problem appears reducing VTT of the liner container vessels. Reference [26] researches the influence of the vessel waiting time on VTT. In reference [27], the correlation between VTT and the average waiting time for ships arriving from sea, and the average number of ships waiting for a berth is investigated. The results presented in reference [28] conclude that port concession has positively and significantly affected VTT. Authors of reference [29] analyze VTT as a port's operational indicator in terms of capability, efficiency, and productivity. References [13,14,16,30-32] are dealing with VTT too. A detailed review of additional references related to VTT is given in references [31,32].

The available port efficiency studies have dominantly been focused on container ports, which is stated in references [12,28].

In the available literature, numerous methods used for researching VTT can be found: the Analytic Hierarchy Process method [18], statistical tools of correlation analysis and trend analysis [21], simulation model [23], stochastic model [26], queuing theory [27], survey research design, stratified sampling technique [28], regression analysis model [17,28], etc.

The structure of VTT (structure given in reference [33], adjusted by author) is as follows: Component T_1: Waiting at port anchorage; Component T_2: Sailing and maneuvering in – to the berth; Component T_3: Time “at berth”; Component T_4: Sailing and maneuvering out – away from the berth.

The structure of the Component T_3 – time “at berth” is: Component T_{31} – pre-loading time; Component T_{32} – loading time; Component T_{33} – after-loading time.

Influential factors on VTT are identified by different authors: the number of container moves, crane intensity, gross crane productivity, berth productivity, time-related variables [30]; economic factors, technical factors, operational/administrative factors, transport, handling and storage [20]; vessel traffic/vessels calls [21]; cargo throughput, port revenue [22]; approaching channel schedule [23]; port infrastructure [24]; cargo plan [25]; waiting time of a vessel [26]; waiting time of a vessel arriving from sea and number of vessels waiting for berth [27]; etc.

Research on dry bulk carriers' turnaround time had no priority in available literature: e.g. references [25-27] are related to containers, reference [29] refers to petroleum, etc. It is one of the initial motives of the author to conduct the research presented in this paper.

Based on the established data series, the statistical modeling of the correlation between the values of the vessel (the dry bulk carrier) loading time and selected key influential factors, using the multiple linear regression model, is done. Concrete data and results are related to the dry bulk cargo terminal in the Port of Bar JSC (Montenegro) for the period from the year 2017 to the year 2021 [34].

2. Data and Methods

In the throughput structure at the dry bulk cargo terminal in the Port of Bar JSC for the period from the year 2017 to the year 2021, bauxite was dominating (export, relation: open storage area to vessel – dry bulk carrier), with a share of 44.6% [34], and as concrete bases of research data series related to dry bulk carriers (39 vessels) loaded with bauxite in the mentioned period are taken.

Data series - Based on the reports from the Port of Bar Information System [34], data series are established (Table 1).

Table 1 Data series. Source: [34]

vessel	T_{1i} (h)	T_{2i} (h)	T_{3i} (h)	T_{bi} (h)	Q_i (t)	$NGCs_i$	$NMHCs_i$	$t_{int-ext-i}$ (h)	$t_{int-int-i}$, (h)
1	5.9	159.3	10.8	176.0	94,794.8	2	1	21.42	0
2	23.3	91.2	4.0	118.5	66,540.7	3	1	17.83	0
...									
39	2.8	67.0	4.3	74.0	45,238.6	2	2	0	0

where: T_{1i} (h) – pre-loading time; T_{2i} (h) – loading time; T_{3i} (h) – after-loading time; T_{bi} (h) – time "at berth"; Q_i (t) – cargo quantity (loaded); $NGCs_i$ – number of used gantry cranes per vessel; $NMHCs_i$ - number of used mobile harbour cranes per vessel; $t_{int-ext-i}$ (h) – loading process interruptions caused by external factors; $t_{int-int-i}$ (h) – loading process interruptions caused by internal factors;

2.1 Multiple Linear Regression Modeling

Regression modeling is a tool for solving complex problems with undefined interaction [35]. It is used for a very wide variety of research: to predict vessel turnaround time [14], for a vessel repair time estimation [35], to define the relationship between initially estimated and finally achieved construction time [36], for modeling and assessment of transport services [37], for establishing correlations between vessel characteristics [38], for the analysis of parameters in the improvement of the decision-making process [39], etc.

To conduct research whose results are shown in this paper, the multiple linear regression model is used. If n is the number of observations of "vessel loading time" (y), which is a dependent variable, there will be n times k number of independent-variable observations (x_{ki}). These observations can be given in a form defined by the following equation [40]:

$$y_i = b_{0i} + b_{1i}x_{1i} + b_{2i}x_{2i} + \ldots + b_{k1}b_{ki} \tag{1}$$

where: i = 1, 2, 3, …… n and b_1, b_2, b_3, …, b_k are the regression coefficients which need to be defined in order to create the multiple linear regression model.

In multiple linear regression, the value of the coefficient for each independent variable indicates the size of the effect that variable is having on the dependent variable, and the sign on the coefficient (positive or negative) indicates the direction of the effect [41]. The multiple linear regression model can be given with a residual part as:

$$y_i = b_{0i} + b_{1i}x_{1i} + b_{2i}x_{2i} + \ldots + b_{k1}b_{ki} + e_j \tag{2}$$

The residual part (e_i) has to be minimal in order to have the best prediction model.

Parameters which describe an adequate multiple linear regression model are [35, 40-42]: the coefficient of determination, R^2; Adjusted R^2; The mean squared error (MSE); The standard error (s); Variance Inflation Factor (VIF). The significance of parameters is tested using the following standard (critical) values - tests [40-42]: F statistic, t-statistic, p-value. The test of the adequacy of the mathematical model is to be performed based on the ANOVA (Analysis of Variance) technique, which represents the basic statistical technique in the analysis of experimental data [39]. In principle, the relevance of these relationships, in any application, depends on the relevance of the input data. [38].

3. Results

The dependent variable, y_i, is the "loading time", respecting the fact that loading time has a dominant share in the total time "at berth" – 89.50% - based on the results of a statistical analysis of data give in Table 1.

The independent variables, x_i, are: x_{1i} (Q_i – cargo quantity (loaded)), x_{2i} (NGC_i – number of used gantry cranes per vessel), x_{3i} ($NMHC_i$ – number of used mobile harbour cranes per vessel), x_{4i} ($t_{in\text{-}ext\text{-}i}$ – loading process interruptions caused by external influential factors per vessel), x_{5i} ($t_{in\text{-}int\text{-}i}$ – loading process interruptions caused by internal influential factors per vessel).

The dependent variable - Loading time, y_i, can be defined as a function of influential factors, x_i:

$$y_i = b_{0i} + b_{1i}x_{1i} + b_{2i}x_{2i} + b_{3i}x_{3i} + b_{4i}x_{4i} + b_{5i}x_{5i} + e_j \tag{3}$$

where: x_i – independent variable; e_i – coefficient which represents uncontrollable influences;

Based on the data series established (Table 1), characteristics parameters in the general regression model defined by relation (3) are calculated using appropriate statistical software. The mathematical model is as follows:

$$y = 23.5072 + 0.0016x_1 - 9.4687x_2 - 10.0083x_3 + 0.421x_4 + 0.1511x_5 \tag{4}$$

In the further segments of the paper parameters of the mathematical model (4) are analyzed. The results of the analyses are given in *Tables 2 – 4*.

Table 2 Analysis of the model's parameter. Source: author

Predictor	Coefficient	Estimate	Standard error	t – statistics	p – value
constant	b_0	23.5072	9.7459	2.412	0.0216
x_1	b_1	0.0016	0.0001	16.0107	0
x_2	b_2	– 9.4687	3.1391	-3.0164	0.0049
x_3	b_3	– 10.0083	6.8316	-1.465	0.1524
x_4	b_4	0.421	0.1495	2.8164	0.0081
x_5	b_5	0.1511	0.226	0.6684	0.5085

The estimated value of coefficient b_5 is smaller than its standard error, which indicates that its value could be 0 (that it is not significant).

The value of t-statistics from the student's distribution tables for 37 degrees of freedom and a significance threshold of 95% is 2.021 [40], so it follows that the t-statistics absolute values corresponding to the coefficients b_0, b_1, b_2 and b_4 are greater than the table value and for them the null hypothesis is rejected and the alternative hypothesis with error $\alpha < 0.05$ and certainty $1 - \alpha > 0.95$ accepted. The null hypothesis cannot be rejected for coefficients b_3 and b_5.

p-values of variables x_3 – number of used mobile harbour cranes (0.1524) and x_5 - loading process interruptions caused by internal influential factors (0.5085) are bigger than the adopted significance level of 0.05, and through the following phase of statistical analysis, it will be decided to remove them from the model or not. In principle, the p-value for a coefficient is not indicating the size of the effect that variable is having on the dependent variable [41].

Table 3 Summary of model overall fit. Source: author

R-squared	$r^2 = 0.9495$
Adjusted R-squared	$r^2_{adj} = 0.9418$
Residual standard error	11.1267 on 33 degrees of freedom
Overall F-statistic	124.0583 on 5 and 33 degrees of freedom
Overall p-value	0

Based on the calculated value of r^2 and following Chaddock's scale [40], as that value is within the range from 0.64 to 1, it can be concluded that correlations between dependent and independent variables are very strong. Based on the calculated value of r^2, it follows that with the regression model (4), 94.95% of the variability of the dependent variable is explained by the joint influence of the independent variables. The rest of 5.05% shows the influence of those factors that are not included in the model.

Table 4 Analysis of variance table (ANOVA table). Source: author

Source	df	SS	MS	F-statistic	p-value
Regression	5	76,794.005	15,358.801	124.0583	0
Residual error	33	4,085.5007	123.8031		
Total	38	80,879.5057	2,128.408		

The table value of the F- test, for the level of significance $\alpha = 0.95$ and the number of degrees of freedom 5 (number of independent variables) and 33 (amount of data in the sample - number of independent variables - 1 = 39 - 5 - 1 = 33) is 2.53 [40]. The calculated value of the F test is 124.0583 and is greater than its table value, so the null hypothesis is rejected and the alternative hypothesis that there is an influence of regression is accepted, which means that the analyzed parameter b is significant.

Respecting the fact that two independent variables from the regression model (4) did not pass significance tests, it is necessary to consider some more variants of the model. In that sense, a statistical modelling of some additional variants is done (Table 5). Based on the data series (Table 1), multiple linear regression models per additional variant are defined (Table 5).

Table 5 Multiple linear regression models per analyzed variant. Source: author

Variant	Mathematical model	Independent variables	Comparison of models				
V2	$y = 23.893 + 0.0016x_1 - 9.358x_2 + 0.3414x_3$	x_1 (Q_i – cargo quantity, x_2 (NC_i – number of cranes: gantry + mobile, x_3 (t_{in-t} - loading process interruptions, total: external + internal)	Coefficient	b_0	b_1	b_2	b_3
			Estimate	23.89	0.0016	-9.358	0.341
			Standard error	7.602	0.0001	2.873	0.0927
			t – statistic	3.142	17.150	-3.256	3.684
			p - value	0.003	0	0.003	0.0008
			$t_{critical}$	2.021	2.021	2.021	2.021
			|Coeff.| > Stand. error	yes	yes	yes	yes
			|t-statistic| > $t_{critical}$	yes	yes	yes	yes
			p-value < 0.05	yes	yes	yes	yes
V3	$y = 35.3856 + 0.0015x_1 - 7.3091x_2 + 0.3592x_3$	x_1 (Q_i – cargo quantity, x_2 (NC_{pi} – number of used cranes, “equivalent” number, taking into account capacity x_3 (t_{in-t} - loading process interruptions, total	Coefficient	b_0	b_1	b_2	b_3
			Estimate	35.385	0.0015	-7.309	0.359
			Standard error	11.231	0.0001	2.377	0.092
			t – statistic	3.1507	18.257	-3.074	3.890
			p – value	0.0033	0	0.004	0.0004
			$t_{critical}$	2.021	2.021	2.021	2.021
			|Coeff.| > Stand. error	yes	yes	yes	yes
			|t-statistic| > $t_{critical}$	yes	yes	yes	yes
			p-value < 0.05	yes	yes	yes	yes
V4	$y = 31.4641 + 0.0017x_1 - 13.5535x_2$	x_1 (Q_i – cargo quantity, x_2 (NC_i – number of used cranes: gantry + mobile.	Coefficient	b_0	b_1	b_2	
			Estimate	31.464	0.0017	-13.553	
			Standard error	8.502	0.0001	3.0645	
			t – statistic	3.700	18.806	-4.422	
			p – value	0.0007	0	0.0001	
			$t_{critical}$	2.021	2.021	2.021	
			|Coeff.| > Stand. error	yes	yes	yes	
			|t-statistic| > $t_{critical}$	yes	yes	yes	
			p-value < 0.05	yes	yes	yes	
V5	$y = 48.1596 + 0.0016x_1 - 10.6277x_2$	x_1 (Q_i – cargo quantity, x_2 (NC_{pi} – number of used cranes, “equivalent” number, taking into account capacity	Coefficient	b_0	b_1	b_2	
			Estimate	48.159	0.0016	-10.62	
			Standard error	12.674	0.0001	2.6186	
			t – statistic	3.7997	19.184	-4.058	
			p - value	0.0005	0	0.0003	
			$t_{critical}$	2.021	2.021	2.021	
			|Coeff.| > Stand. error	yes	yes	yes	
			|t-statistic| > $t_{critical}$	yes	yes	yes	
			p-value < 0.05	yes	yes	yes	
V6	$y = 3.6741 + 0.0013x_1 + 0.461x_2$	x_1 (Q_i – cargo quantity, x_2 (t_{in-t} - loading process interruptions, total	Coefficient	b_0	b_1	b_2	
			Estimate	3.6741	0.0013	0.461	
			Standard error	4.9391	0.0001	0.0958	
			t – statistic	0.7439	18.396	4.8144	
			p - value	0.4618	0	0	
			$t_{critical}$	2.021	2.021	2.021	
			|Coeff.| > Stand. error	no	yes	yes	
			|t-statistic| > $t_{critical}$	no	yes	yes	
			p-value < 0.05	no	yes	yes	

4. Discussion

Based on results of variants` evaluation from the aspect of following criteria: the relation between values of regression coefficients, b_i and their standard errors; values of coefficient of determination, r^2; the relation between t-statistic and $t_{critical}$ for the adopted level of significance (0.05) and n-2 degree of freedom (n-number of data in series); the relation between F-statistic and $F_{critical}$ for the adopted level of significance (0.05) and degrees of freedom equal to the number of independent variables, k, and n-k-1; the relation between the p-value and the adopted level of significance (0.05); the level of adequacy of independent variables from the technological and operational points of views; for the best-fit model, variant V3, is selected:

$$y = 35.3856 + 0.0015x_1 - 7.3091x_2 + 0.3592x_3 \quad (5)$$

where the independent variables are: x_1 (Q_i – cargo quantity (loaded)), x_2 (NC_{pi} – number of used cranes per vessel, "equivalent" number: gantry + mobile, taking into account capacity), x_3 (t_{in-t} - loading process interruptions per vessel, total: caused by external + internal factors).

Key characteristic parameters of the selected (best-fit) model (Variant 3) are: R-squared, r^2 = 0.9443; 3.0746 < |t – statistic| < 18.257; $t_{critical}$ = 2.021; overall F-statistic = 197.9197; $F_{critical}$ = 2.92; overall p-value = 0. The value of the constant in the model is 35.3856. When values of other parameters are kept unchanged, loading time increases if the loaded quantity is bigger. Loading time decreases if the number of used cranes increases (under the condition that all other parameters are unchanged) and an increase in loading process interruptions causes an increase in loading time, with other parameters remaining unchanged.

Based on the calculated value of r^2, it follows that with the regression model (5), 94.43% of the variability of the dependent variable is explained by the joint influence of the independent variables. The rest of 5.57% is the influence of those factors that are not included in the model.

Having all defined basic selection criteria satisfied, additional reasons for selecting Variant 3 as the best-fit model can be summarized as follows: Variant 1 (basic variant) of the model is rejected as two of its coefficients were found insignificant; Variant 2 of the model is based on the number of cranes used in the loading process without adequately respecting relations between cranes capacity – so, it is rejected, too; Variant 6 of the model did not pass the significance test and is rejected; values of the coefficient of determination related to Variant 3 of the model are bigger than the ones referred to in variants 4 and 5.

Regardless of the high number of identified influential factors on Vessel Turnaround Time in general and Vessel Loading time as its component with the dominant share, it is obvious that dominant influence is related to cargo quantity (loaded) into a vessel, number of used cranes (respecting the relation between their capacity/productivity) and loading/unloading process interruptions caused by internal and external factors.

5. Conclusion

One of the projected priority purposes of results of this research is creating bases for improving efficiency at a dry bulk cargo terminal (and at a seaport in general) through optimization of vessels' (dry bulk carriers) loading time.

The author plans to continue doing research in this field giving priority to following – **direction 1**: trying to reduce an obvious lack of integral approach which takes into consideration systematization/classification of influential factors in order to establish correlations between them and components of VTT; **direction 2** - testing the level of adequacy of defined mathematical models for loading operations with different types of cargo and identification of necessary adjustments and modeling influence of factors on VTT which cannot be easily quantified.

References

[1] Esmer, S. (2008). Performance Measurements of Container Terminal Operations. Dokuz Eylul University. Retrieved August 1, 2023, from http://www.sbe.deu.edu.tr

[2] Verschuur, J., Koks, E.E. & Hall, J.W. (2022). Ports' criticality in international trade and global supply-chains. Nature Communications 13, 4351. DOI: 10.1038/s41467-022-32070-0.

[3] Jouili, T. (2016). The Role of Seaports in the Process of Economic Growth. Developing Country Studies 6(2), 64-69. Retrieved August 10, 2023, from https://core.ac.uk/download/pdf/234682718.pdf

[4] Zhang, L., Sijia Qu, S. & Jin Dai, J. (2021). Port Capability Evaluation from the Perspective of Supply Chain. Journal Discrete Optimisation for Complex and Smart Transportation Systems 2021. DOI: 10.1155/2021/7633202.

[5] Mudronja, G., Jugović, A. & Škalamera-Alilović, D. (2020). Seaports and Economic Growth: Panel Data Analysis of EU Port Regions. Journal of Maine Science and. Engineering 8(12), 1017. DOI: 10.3390/jmse8121017.

[6] Munim, Z.H. & Schramm, H.-J. (2018). The impacts of port infrastructure and logistics performance on economic growth: the mediating role of seaborne trade. Journal of Shipping and Trade 3(1). DOI: 10.1186/s41072-018-0027-0.

[7] Dwarakisha, G.S. & Salima, A.M. (2015). Review on the Role of Ports in the Development of a Nation. Aquatic Procedia 4, 295 – 301. DOI: 10.1016/j.aqpro.2015.02.040.

[8] Somu, R., Jeevan, J., Mohd Salleh, N.H., Othman, M.R., Mokhtar, K. & Ngah, A.H. (2022). The role of seaports in regional development in the East Coast of Peninsular Malaysia: An evaluation through an exploratory factor analysis. Journal of Transport and Supply Chain Management 16. DOI: 10.4102/jtscm.v16i0.617.

[9] Tareq, A.M., Shaikh, M.A., Sen, S. & Xuefeng, W. (2020). Deep Sea Port and the National Development: Perspective of Bangladesh. International Journal of Engineering and Management Research 10(6), 73-80. DOI: 10.2139/ssrn.3775408.

[10] Zaucha, J. & Matczak, M. (2018). Role of maritime ports and shipping in the creation of the economic value of the sea areas. SHS Web of Conferences 58, 01033, 2018 (pp. 1-9). Retrieved September 12, 2023, from https://www.shs-conferences.org/articles/

[11] Pallis, A. & Rodrigue J.P. (2022). Port Efficiency. In: Port Economics, Management and Policy, Chapter 6.2. Retrieved September 10, 2023, from https://porteconomics management.org

[12] Merk, O. & Dang, T. (2012). Efficiency of world ports in container and bulk cargo (oil, coal, ores and grain). OECD Regional Development Working Papers. 2012/09. DOI: 10.1787/5k92vgw39zs2-en.

[13] Goodchild, A.V. & Daganzo, C.F. (2005). Crane Double Cycling in Container Ports: Effect on Ship Dwell Time. Institute of Transportation Studies University of California at Berkeley. Research Reports B-ITS-RR-2005-5. Retrieved September 21, 2023, from https://escholarship.org/content/qt9qp7p7jq/qt9qp7p7jq_noSplash_95c601a0615c6c50b0b249 96cd8616a7.pdf

[14] Stepec, D., Martincic, T., Klein, F., Vladusic, D. & Costa, J.P. (2021). Machine Learning based System for Vessel Turnaround Time Prediction. DOI: 10.1109/MDM48529.2020.00060.

[15] Studer, K.R. (1969). A Study of ship size and turnaround time in the Port of Vancouver. The University of British Columbia. Retrieved October 1, 2023, from https://open.library.ubc.ca

[16] Goodchild, A.V. & Daganzo C.F. (2004). Reducing Ship Turn-Around Time Using Double-Cycling. Institute of Transportation Studies, University of California at Berkeley, Research Reports. Retrieved August 12, 2023, from https://escholarship.org/uc/item/86r4p6sc

[17] Robinson, R. (1978). Size of Vessels and Turnaround Time: Further Evidence from the Port of Hong Kong. Journal of Transport Economics and Policy 12(2), 161-178. Retrieved August 28, 2023, from https://www.jstor.org

[18] Gayathma, K., Sigera, I. & Cahoon, S. (2015). The factors affecting the container vessel turnaround time at Port of Colombo. Proceedings of the IAME 2015 Conference (pp. 1-17). Retrieved September 5, 2023, from https://figshare.utas.edu.au/articles//conference_contribution/The_factors_affecting_the_conta iner_vessel_turnaround_time_at_Port_of_Colombo/23095535

[19] Balamwar, A., Tuhin Subhra De, T., Das, D. & Manoj Kumar Tiwari, M.K. (2022). Prediction of Turn Around Time using Neural Networks - A Case Study of Shipping Ports. IFAC PapersOnLine 55(10), 389–394. DOI: 10.1016/j.ifacol.2022.09.424.

[20] Mbanefo, H.C. (2020). Development of Nigerian Ports for Organizational Efficiency and Faster Turnaround Times. RSU Journal of Strategic and Internet Business 5(1), 845-859. Retrieved September 21, 2023, from https://www.rsujsib.com/wp-content/

[21] Osondu-Okoro, C.G., Nwokedi, T.C., Mbachu, J.C., Ogwo, N.E. & Nwachukwu, J.O. (2022). Ship Turnaround Time and Vessel Traffic in Nigerian Ports: A Correlation Analysis. European Journal of Maritime Research 1(1), 19-24. DOI: 10.24018/maritime.2022.1.1.3.

[22] Buhari, S.O., Ndikom, O. & Theophilus, N. (2017). An Assessment of the Relationship Among Cargo-Throughput, Vessel Turnaround Time and Port-Revenue in Nigeria. Journal of Advance Research in Business Management and Accounting 3(7). DOI: 10.53555/nnbma.v3i7.54

[23] Kuznetsov, A.L., Kirichenko, A.V. & Semenov, A.D. (2020). Evaluation of ship turnaround time in port with approach channel. Scientific Journal of Gdynia Maritime University 115(2020), 31–41. Retrieved, August 29, 2023, from https://ojs.umg.edu.pl/

[24] Monday, E.I., Emenike, G.C. & Ibe, C.C. (2021). Assessment of Vessel Turnaround Time in Eastern Nigerian Ports. International Journal of Research and Innovation in Social Science V(VI), 71-74. Retrieved September 30, 2023, from www.rsisinternational.org

[25] Kuznetsov, A., Kirichenko, A. & Zboinov, A. (2020). Influence of a cargo plan on the container ship port turnaround time. XXII International Scientific Conference EMMFT-2020, E3S Web Conf. 244 (2021). Retrieved August 11, 2023, from https://www.e3s-conferences.org/articles/e3sconf/abs/2021/20/e3sconf_emmft2020_08011/

[26] Elentably, A., Fisher, K., Holger, S., Alghanmi, A. & Alhrbi, S. (2022). Stochastic Model to Estimate the Waiting Time for Container Vessel Turnaround Times. The International Journal on Marine Navigation and Safety of Sea Transportation 16(3), 515-519. Retrieved August 9, 2023, from https://www.transnav.eu

[27] Jones, J.H. & Blunden, W.R. (1968). Ship Turn-Around Time at the Port of Bangkok. Journal of the Waterways and Harbors Division 94(2), 135-148. DOI: 10.1061/JWHEAU.0000557.

[28] Okeke, A.F. (2022). Port Concession and Ship Turnaround Time in Nigerian Ports. Himalayan Journal of Economics and Business Management 3(3), 42-49, Retrieved September 8, 2023, from https://himjournals.com/articles/

[29] Ming, N.S. & Shah, M.Z. (2008). Petroleum Terminal`s Operation Process on Vessel Turnaround Time. Proceedings from EASTS International Symposium on Sustainable Transportation. Retrieved September 15, 2023, from https://web.itu.edu.tr/~keceli/

[30] Premathilaka Wajira, H.V. (2018). Determining the factors affecting the turnaround time of container vessels: a case study on Port of Colombo. World Maritime University. Retrieved September 15, 2023, from https://commons.wmu.se/

[31] Kokila, A.V. & Abijath, V. (2018). Reduction of Turnaround Time for Vessels at Cochin Port Trust. International Journal of Pure and Applied Mathematics 117(20), 917-922. Retrieved August 11, 2023, from https://acadpubl.eu

[32] Mokhtar, K. & Shah, M.Z (2006). A Regression model for vessel turnaround time. Retrieved July 28, 2023, from https://d1wqtxts1xzle7.cloudfront.net/

[33] Shanthirathne A. (2023). How to Improve Port`s Productivity/Efficiency? Sri Lanka Ports Authority. Retrieved August 31, 2023, from http://www.iaphworldports.org

[34] Port of Bar (2022). Documentation of the Development Department.

[35] Awal, Z.I. & Abdullah, A. (2020). Multiple Linear Regression Model for Ship Repair Time Estimation, Proceedings from the 12TH International conference on Marine Technology MARTEC. Retrieved August 13, 2023, from http://zobair.buet.ac.bd/

[36] Aiyetan, A.O., Smallwood, J.J. & Shakantu, W. (2012). A linear regression modelling of the relationship between initial estimated and final achieved construction time in South Africa. Journal Acta Structilia 19(1), 39-56. DOI: 10.38140/as.v19i1.121.

[37] Borucka, A. (2020). Logistic regression in modeling and assessment of transport services. Open Engineering. DOI: 10.1515/eng-2020-0029.

[38] Lee, H.T., Yang, H. & Cho, I.S. (2021). Data-Driven Analysis for Safe Ship Operation in Ports Using Quantile Regression Based on Generalized Additive Models and Deep Neural Network Sensor. DOI: 10.3390/s21248254.

[39] Ilic, Dj. & Mijailovic, S. (2014). Regression analysis of parameters in the improvement of decision making processes. Business trends (in Serbian) II(4), High Business School, Krusevac.

[40] Popovic, B. & Popovic, P.M. (2018). Statistical modeling (in Serbian), University of Nis. Retrieved August 1, 2023, from https://www.pmf.ni.ac.rs/download/IZDANJA-KNJIGA-PMF_2/matematika/knjiga1-1.pdf

[41] Princeton University Library. (2007). Interpreting Regression Output. Retrieved August 2, 2023, from https://dss.princeton.edu/online_help/analysis/interpreting_regression.htm

[42] Igushkin, I, Shikhalev, A., Vorontsov, D, Verzun, N., Kolbanyov, M. & Akhmetova, I. (2022). Student's t-table modification for the linear correlation coefficients estimation in the small samples cases. Proceedings from VIII International Conference ITNT-2022. Retrieved August 9, 2023, from https://ieeexplore.ieee.org/document/9848663