TPM Vol. 32, No. S7, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

ANALYSIS OF KEY SUCCESS FACTORS OF DIGITAL COLLABORATION IN INDONESIA MARITIME LOGISTICS

DAVID RAHADIAN[1], R.O. SAUT GURNING[2]

[1] MARINE ENGINEERING, INSTITUT TEKNOLOGI SEPULUH NOPEMBER, SURABAYA, INDONESIA.
[2] MARINE ENGINEERING, INSTITUT TEKNOLOGI SEPULUH NOPEMBER, SURABAYA, INDONESIA.
EMAIL: [1]7019242002@student.its.ac.id, [2]sautg@its.ac.id

ORCHID ID: [1] 0000-0003-2818-0632, [2] 0000-0002-4328-7916

ABSTRACT:
As Maritime Logistics plays an important role in Goods Transportation, Indonesia is still struggling to improve its Logistics Performance Index. The government has been boosting Port Digitalization, but it has not given a significant reduction in Logistics Costs. The collaboration among Port Stakeholders as the hub of the Maritime Logistics Community is considered the key to improvement. The purpose of this paper is to explore and find out the elements of Collaboration that become the Key Success Factors to improve Maritime Logistics Performance.
The authors scrutinize the elements of digital collaboration in Maritime Logistics, then utilize surveys and interviews as a data collection method, from the Port Stakeholder as the key player in Maritime Logistics. This paper conducts a partial least-square structural equation method (PLS-SEM) to meet the research objectives.Based on the literature review, the key success factor of Digital Collaboration is developed. Furthermore, it is found that Digital Collaboration has the potential to improve Maritime Logistics Performance.
KEYWORDS: Digitization, Collaboration, PLS-SEM, Maritime Logistics, Logistics Performance.

INTRODUCTION:

As a maritime country, Indonesia, with 17.499 islands, significantly relies on maritime logistics to connect these islands. Port is the most essential part of the sea transportation network, also affected by Industry Revolution 4.0 [7]. More than 1,28 billion metric tons of cargo were handled in all of Indonesia's Ports in 2021, based on the Sea Transportation Statistic Report [4].
Seaports are crucial in modern global supply chain networks and systems since they account for more than 80% of international trade [5]. Port Operation and Shipping and Freight Forwarding become three critical parts of maritime logistics [12].
Maritime logistics efficiency become the key to expanding the local economy. However, as an archipelago country, Indonesia needs help achieving maritime logistics system efficiency. The Logistics Cost in Indonesia was 26.03% of the Gross Domestic Product (GDP), based on a World Bank report in 2013 [2]. Still, the Logistics Cost in Indonesia is the highest among ASEAN Countries since it still held 23.2% of GDP in 2019 [17].
Based on the World Bank Report, Indonesia's Logistics Performance Index (LPI) year 2023 is dropping 17 to number 61, lower from rank 46 in LPI 2018. Four dimensions are dropping: timeliness from 3.7 to 3.3; tracking and tracing from 3.3 to 3.0; the infrastructure factor, as well as competence and equality, got a score of 2.9; and Customs become the lowest of 2.8 [3].
Digitalization as the result of Industrial Revolution 4,0 bringing new terms, such as Big Data, Internet of things (IoT), and cloud computing, to Regulation changes to adapt to the times are unavoidable. It should be applied since it simplifies the course of an activity, improving effectiveness and efficiency, either in terms of time or costs [8]. Adopting digitalization or digital transformation should be the main ingredient in maritime logistics activities in Indonesia [10].
Covid-19 has accelerated the digitalization of global supply chain networks. Suppose ports become the weak link in the maritime logistics chain. In that case, they risk inducing delays, late payments, inefficient costs, energy consumption and emissions waste, safety and security concerns stemming from a lack of traceability. Ports become the key to enabling supply chain resilience and green conversion of the global supply chain, a must in pandemic times and beyond [13].
However, According to Acciaro [1], despite the increasing number of digitalization efforts that can be traced in the industry, little is known of the processes and mechanisms that make digitalization successful, with the result that initiatives are often uncoordinated, unfocused, poorly managed, and do not deliver the expected results. There needs to be more alignment between innovation actions and strategy in maritime logistics firms.

Along with that, Tijan [18] also addresses lack of cooperation and collaboration, lack of capabilities to change, employees and manager's resistance to change, lack of employees' and managers' motivation, lack of urgency, vision, strategy are among the barrier of digital transformation in maritime logistics.
Kim (2022) evaluates the extent of collaboration between shippers and shipping companies in South Korea. By analyzing 167 responses from Shipping Companies using the Exploratory Factors Analysis weighting method, it is found that Cooperative and Collaborative Spirit Indices-CCSI indicate that influential supply chain members resist two-way communication, mutuality, distributive fairness, and long-term relationships. Managerial and political initiatives are discussed to reduce barriers to interaction and facilitate the CCSI level between supply chain members.
The study aims to find out the elements of Digital Collaboration that become the Key Success Factors to improve Maritime Logistics Performance.

2) CONCEPTUAL FRAMEWORK

From the literature review of the source of Digital Collaboration, it is found there are some factors initiating the transformation. By a comprehensive literature review, Tijan [18] found that there are some factors, such as regulations, competition, technology, and internal organization itself, such as cost reduction, streamlining operations, and shorter time delays. Along with that, Jovic [11] found that the factors are technological, organizational, and environmental, which include Regulation, competition, social responsibility, and standards.
Verhoef [20] mentions stages in digital collaboration. The factors of successful implementation are digital resources, organization structure, strategies, and metrics. Ritonga [16] studied the smart port implementation readiness in Indonesia. Four aspects are assessed, namely human resource management, the level of usefulness of information technology (IT) at the port, the level of use of IT at the port, and the level of service of IT information resources/ port digitalization. Using descriptive statistics, it finds that the human resources aspect has the lowest score.
Iman [10] studied Maritime Supply Chain Improvement by Digitization, applying the Technology Acceptance Model as a tool to measure perceived usefulness (PU) and perceived ease of use (PEU) of Technology implemented. It also employed Principle Component Analysis (PCA) to examine which factors correlate with one another regarding utilizing digital port services. It finds that digitalization should be prioritized, Intention to Use (ITU) will increase when PU is high, and negative trust will reduce the ITU.
Bagus [5] found the seaport-fulcrum risks are stakeholder coordination, cargo imbalances, security inspection, port strikes, and Covid-19. Raza [14] found there are three major challenges in digital collaboration: technological, governance and organizational, and operational.
Finally, Razmjooei [15] makes a bibliometric of Industry 4.0 research in the Maritime Industry. It noticed that digitalization technology become the most addressed issue. The top three country collaboration networks object are China, USA, and South Korea, while Heillig becomes the most cited researcher in this area. Hacardiaux [9] finds that collaboration in logistics can reduce costs.
To conduct the quantitative analysis, the authors defined the constructs. The constructs and respective measurement items (factors) are presented in Table 1.

Table 1: Constructs and Items

Construct	Items (Sub Construct)	Sources
Regulation	R1 system implementation Socialization	Tijan (2021)
	R2 system input problem Support	Jovic (2022)
	R3 inputted data Transparency	Bagus (2022)
	R4 data usage level of Confidence	Raza (2023)
Organization	O1 Organization vision and mission Clarity	Acciaro (2020)
	O2 Economic benefit of system inplementation	Tijan (2021)
	O3 Financial readiness to implement	Verhoef (2021)
	O4 Human Resource readiness to implement	Jovic (2022)
	O5 Organization readiness to collaborate	Raza (2023)
		Razmjooei (2023)
Technology	T1 System Opennes to be accessible	d'Amico (2021)
	T2 System data Security	Tijan (2021)
	T3 Investment required	Verhoef (2021)
	T4 Need of HR, Tools, System for implementation	Jovic (2022)
		Ritonga (2022)
		Iman (2022)
		Raza (2023)
Maritime Logistic Performance	MLP 1 Infrastructure Readiness	Acciaro (2020)
	MLP2 Logistics Cost	Amin (2021)
	MLP3 Logistics Competency	Lind (2021)

	MLP4 Time Accuracy	Arvis (2023)
	MLP5 Service Quality	Hacardiaux (2022)

3] METHODOLOGY

After the literature review, the authors designed a questionnaire and collected quantitative data on factors influencing digital collaboration in the maritime logistics sector through an online survey. A five-point Likert-type scale (1—totally disagree, 5-totally agree) was used to measure the level of agreement with given statements on the questionnaire. For data analyses, the partial least squares structural equation modeling (PLS–SEM) method was used to test the model, first, the outer model to check validity and reliability, and then the inner model, using SmartPLS 3.
Wendler-Bosco [19] mentioned parties involved in Maritime Logistics: The Port/Terminal Operator, Public Institution (Port Authority, Customs, Local Government), Vessel and Shipping Companies (which also include shipping agencies, Shippers or manufacturers (Cargo Owner), Intermodal logistics provider or freight forwarders, Community, Researchers.
The authors contacted 83 respondents within the Indonesian Maritime Logistics communities from seven types of organizations and got 76 valid responses.

4] RESULTS

4.1. Respondent Characteristics

Out of 76 valid responses, mostly aged above 50 and between 31-40. It is in line with the position, in which most of the responders are Managers (28.9%) and Directors (27.6%), and their education is mostly Bachelor's (51.3%) and Master's degree (25%). At the same time, there are 4 PhDs also participating, which could indicate the survey is being responded to by qualified personnel. The respondents mostly come from the Port Company (44.7%) and the Shipping Company (14.5%).
Most respondents are users of Pelindo Port only (35.5%) and Non-Pelindo Port only (27.7%), the major commercial port in Indonesia. It is in line with the users of Inaportnet only (47.4) and Port TOS (26.3%) only user, implying they are the main actors in Port.

4.2. Measurement Model

The author tested the measurement or outer model in the first part of the PLS–SEM analysis. We evaluated composite reliability and convergent validity, and then assessed the discriminant validity and evaluated the composite model.
The reliability test is used to see the stability or consistency of measurement results. A measuring tool is reliable if used repeatedly on one object to produce the same results. The reliability technique used is the reliability of consistency between items; the author uses the Cronbach alpha test. A construct or variable is declared reliable if it gives a Cronbach's Alpha value > 0.70 [6]. Partial Least Square (PLS) can use two methods, namely Composite Reliability (CR) and Cronbach's Alpha. The test results in Table 2 show that the Composite Reliability (CR) value is greater than 0.7 and the Cronbach's Alpha value is greater than 0.6, so it can be concluded that the data is reliable, indicating that all indicators consistently measure each variable.

Table 2: Construct Reliability Test

Construct	Cronbach's Alpha	Composite Reliability
Maritime Logistics Performance (MLP)	0.935	0.951
Organization (ORG)	0.929	0.946
Regulation (REG)	0.882	0.919
Technology (TEC)	0.882	0.917

Convergent validity is carried out to test the level of accurate items to measure the research object. In this study, a factor loading test. According to Benitez [6], an item has convergent validity if the factor loading score exceeds 0.7. The result is shown in Figure 1, where all factor (outer) loading is above 0.7, meaning that all items are Valid. Meanwhile, R2 gives the highest score, 0.904, which means that R2 is the most potent factor.

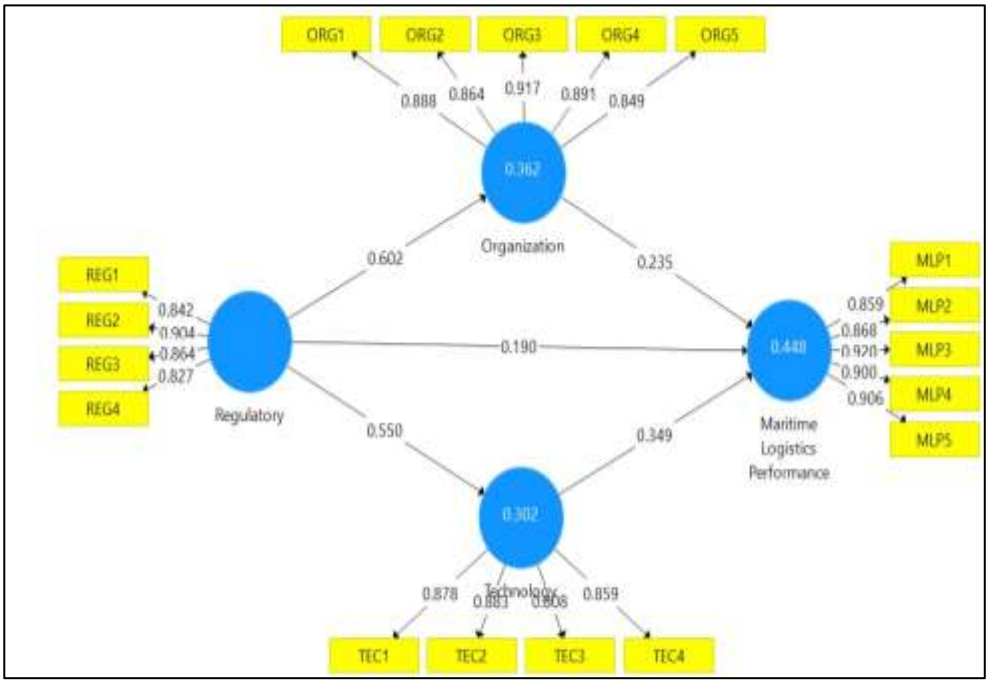

Figure 1: Full Structural PLS Model: Convergent Validity

Discriminant validity entails that two latent variables that are meant to represent two different theoretical concepts are statistically sufficiently different. This evaluation was carried out by comparing the square root of each latent variable's average variance extracted (√AVE) value with the correlation between other latent variables in the model. The results of the discriminant validity test showed that the AVE value was greater than 0.50 [6], and the four latent variables studied had a square root of average variance extracted (√AVE) value greater than the correlation coefficient between the other variables, as shown in Table 3. Thus, the results obtained indicate that they have good discriminant validity.

Table 3: Discriminant Validity Test

Construct	AVE	√AVE	MLP	ORG	REG	TEC
Maritime Logistics Performance	0.794	0.891	0.891			
Organization	0.779	0.883	0.578	0.883		
Regulation	0.739	0.860	0.524	0.602	0.860	
Technology	0.736	0.858	0.607	0.654	0.55	0.858

The multicollinearity test is used to test whether there is a very significant relationship between the independent variables. Techniques that can be used to detect multicollinearity include examining the correlation matrix. A VIF (Variance Inflation Factor) value above 4 indicates the presence of collinearity symptoms in the research model [6]. The result in Table 4 shows all VIFs below 4, which is why we do not expect problems related to multicollinearity.

Table 4: Multicollinearity Test Result

Collinearity	VIF
ORG --> MLP	2.048
REG --> MLP	1.680
TEC --> MLP	1.872
REG --> ORG	1.000
REG --> TEC	1.000

4.3. Structural Model Analysis

Testing is carried out by looking at the Path Value to see whether it has a significant effect or not. In this research, boostraping was carried out with a subsample of 500 and a significance level of 0.05 (two tail). Based on testing the full structural model using the bootstrapping method, it is shown in Figure 2.

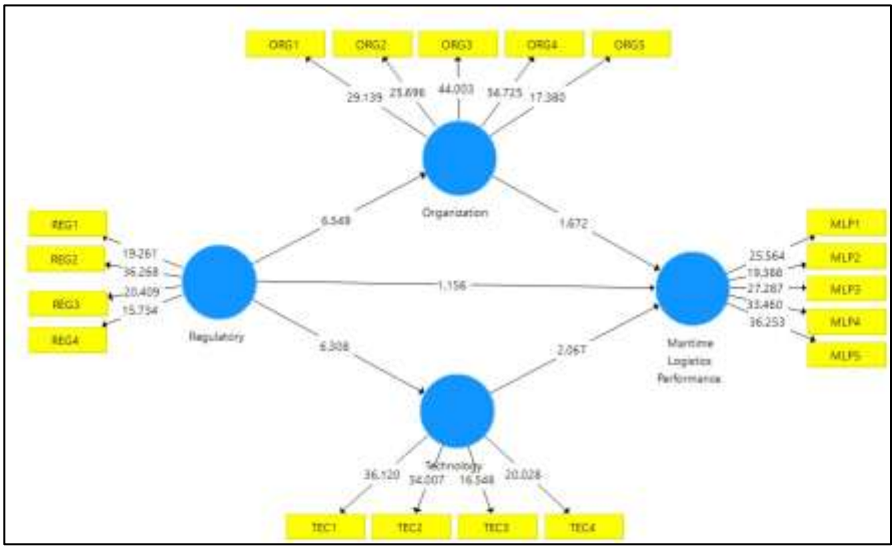

Figure 2: Path Analysis Full Model (Bootstrapping)

Path Coefficient is used to see the relationship between constructs; the value ranges from -1 to +1. The closer to +1, the stronger the relationship between the constructs; the closer to -1, the more negative the relationship between constructs. The result in Table 5 shows that the smallest path value is the Regulation influence on Maritime Logistics Performance of 0190. Meanwhile, the largest path value is the Regulation influence on the Organization of 0.602.

Table 5: Path Coefficient Analysis

Path	Path Coefficient
REG --> ORG	0.602
REG --> TEC	0.550
REG --> MLP	0.190
ORG --> MLP	0.235
TEC --> MLP	0.349

The influence of the dependent variable can be displayed by the R-square value. Through the coefficient of determination (R^2) value contained in Table 6, it can be seen that substructure 1 has an R2 value for the MLP variable of 0.448, which shows that the MLP variable can be explained by 44.8% by the REG, ORG, and TEC variables. Meanwhile, sub-structure 2 has an R^2 value for the ORG variable of 0.362, which shows that the ORG variable can be explained by 36.2% by the REG variable. Substructure 3 has an R^2 value of the TEC variable of 0.302, which shows that the TEC variable can be explained by 30.2% by the REG variable.
The structural model is evaluated by paying attention to the Q2 predictive relevance model, which measures how well the model produces the observation values. Q2 is based on the coefficient of determination of all dependent variables. The Q2 quantity is $0 < Q2 < 1$; the closer the value is to 1, the better the model. The Q2 predictive relevance model calculation results give a value of Q2 = 0.754, which is close to 1, so it can provide evidence that the structural model has an excellent goodness-of-fit.
The f2 effect size value of ≥ 0.02 indicates a small effect size, ≥ 0.15 indicates a medium effect size, and≥ 0.35 indicates a large effect size [6]. Based on the effect size value above, it can be seen in Table 6 that the smallest effect size value is 0.039; the influence of Regulations on Maritime Logistics Performance has a small effect. Meanwhile, the largest effect size value is 0.568, namely, the influence of Regulations on the organization has a large influence.

Table 6: Structural Model Evaluation

Endogenous Variable	**R^2**	**Interpretation**
Maritime Logistics Performance	0.448	Average Relationship
Organization	0.362	Average Relationship
Technology	0.302	Average Relationship
Cohen's Effect Size	**f^2**	**Interpretation**
ORG --> MLP	0.049	Small Effect
REG --> MLP	0.039	Small Effect
TEC --> MLP	0.118	Small Effect
REG --> ORG	0.568	Large Effect
REG --> TEC	0.433	Large Effect

4.4. Hypothesis Test

The hypothesis is tested using path coefficient values and t values to see whether there is a significant effect. Apart from that, the results of the path significance test also show the parameter coefficient values, which show the significance value of the influence of each research variable. In this study, researchers used a confidence level of 95%. The path coefficient score indicated by the T-statistic value must be above 1.64, and the p-value must be < 0.05. The result is shown in Table 7.

Table 7: Hypothesis Test Result

Hipotesis	Original Sample (O)	T Statistics (|O/STDEV|)	P Values	Result
H1 REG → ORG	0.602	6.603	0.000	Accepted
H2 REG → TEC	0.550	6.086	0.000	Accepted
H3 REG →MLP	**0.190**	**1.149**	**0.125**	**Rejected**
H4 ORG → MLP	0.235	1.691	0.046	Accepted
H5 TEC → MLP	0.349	2.023	0.022	Accepted
H6 REG →ORG → MLP	**0.142**	**1.478**	**0.070**	**Rejected**
H7 REG →TEC →MLP	0.192	2.013	0.022	Accepted

5] CONCLUSION

The main objective of this research is to find the factors in the digital collaboration that affect Maritime Logistics Performance. It is found that the regulation doesn't have either a direct impact or indirect impact through organization factors on Maritime Logistics Performance. Meanwhile, Organizational and Technological Collaboration and Regulation through Technological Collaboration have an impact on Maritime Logistics Performance

The Impact of Organizational and Technological Collaboration on Maritime Logistics Performance is in line with Tijan [18], Jovic [11], Ritonga [16], and Raza [14]. The Impact of Organizational and Technological Collaboration on Maritime Logistics Performance is in line with Tijan [18], Jovic [11], Ritonga [16], and Raza [14]. It means that the Government's effort is not only to build digitalization but should foster Human Resources and Organizations to transform the culture into digitalization as the key to improving maritime logistics performance. The Organizational factors, such as vision and mission clarity, the economic benefit of digital collaboration, organization, and human resource development, are crucial and must be supported by its financial health. The technological factors should address connectivity to a public system, data security, wise investment, and provision of know-how and tools.

The Organization should develop effective digital transformation, and it is essential to measure the clear metrics or KPIs [20] to avoid becoming digital fashionistas [14]. The digital collaboration should aim for economic benefit, which is in line with other logistics collaborations [9]

Furthermore, this research enriches the literature regarding Maritime Logistics Performance and Digital Collaboration in Indonesia's Maritime Sector, which could explain the obstacles to improving the Indonesian Logistics Performance Index.

The study has a limited number of respondents and is applicable in the Jawa Area, which is most populated and developed in Indonesia and mainly has a developed port. Future research is expected to explore a more comprehensive area coverage in Indonesia to picture the whole problem, either Non-Jawa port or the broader ecosystem of Maritime Logistics.

By conducting a broader scope and area, it is believed that future research can explore more extensive samples that enable the conduct of a Covariance-Based Structural Equation Model rather than using Partial Least Square as Variance-Based SEM. It is understood that PLS can only predict the model and still needs a CB SEM to provide confirmatory and parameter accuracy.

Additionally, it is essential to evaluate the technological, financial, sociological, or regulatory gap and obstacles of digital culture that clog the implementation.

6] Acknowledgement: Authors express their gratitude to the respondents for their invaluable and constructive comments on the research.

7] Funding Statement: The authors did not receive financing for the development of this research.

8] Data Availability: The data that support the findings of this study are available from the corresponding author.

9] Conflict of interest : The authors declare that there is

10] REFERENCES

[1] Acciaro, M., Sys, C.: Innovation in the maritime sector: aligning strategy with outcomes. Maritime Policy & Management. 47(8), 1045-1063 (2020) https://doi.org/10.1080/03088839.2020.1737335
[2] Amin, C., Mulyati, H., Anggraini, E., Kusumatranto, T.: Impact of maritime logistics on archipelagic economic development in eastern Indonesia. The Asian Journal of Shipping and Logistics. 37, 157-164 (2021)
[3] Arvis, J.: Connecting to Compete 2023: Trade Logistics in Uncertain Economy: Logistics Performance Index and Its Indicator. World Bank https://lpi.worldbank.org/sites/default/files/2023-04/LPI_2023_report.pdf. (2023)
[4] Badan Pusat Statistik: Statistik Transportasi Laut 2021. BPS RI, Jakarta (2022)
[5] Bagus, M.R.D., Hanaoka, S: The Central Tendency of The Seaport-Fulcrum Supply Chain Risk in Indonesia Using a Rough Set. The Asian Journal of Shipping and Logistics. 38, 222-233 (2022)
[6] Benitez, J., Henseler, J., Castillo, A., Schuberth, F.: How to perform and report an impactful analysis using partial least squares: Guidelines for confirmatory and explanatory IS research. Inf. Manag., 57, 103168 (2020)
[7] Cahyawati, A.N., Kusuma T.W.N., Kartika Sari, S.I.: Design Of Digitalization Of Lamong Bay Terminal Service System In Supporting Indonesian Sea Toll Program With Quality Function Deployment (QFD) Approach. Journal of Innovation and Applied Technology. 8(2), 1444-1450 (2022)
[8] D'Amico, G., Szopik-Depczynska, K., Dembinska, I., Ioppolo, G.: Smart and sustainable logistics of Port cities: a framework for comprehending enabling factors, domains and goals. Sustainable Cities and Society. 69, 1-19 (2021)
[9] Hacardiaux T., Tancrez J.S.: Assessing the benefits of horizontal cooperation for the various stages of the supply chain. Operational Research. 22, 3901–3924 (2022)
[10] Iman, N., Amanda, M.T., Angela, J.: Digital transformation for maritime logistics capabilities improvement: cases in Indonesia. Marine Economics and Management. 5(2), 188-212 (2022)
[11] Jovic, M., Tijan, E., Vidmar, D., Pucihar, A.: Factors of Digital Transformation in the Maritime Transport Sector. Sustainability. 14, 9776 (2022). https://doi.org/10.3390/su14159776
[12] Lee, P.T.-W., Lam, J.S.L., Lin, C.-W., Hu, K.-C., Cheong, I.: Developing the fifth generation port concept model: an empirical test. The International Journal of Logistics Management. 29(3), 1098-1120 (2018). https://doi.org/10.1108/IJLM-10-2016-0239
[13] Lind, M., Lehmacher, W., Knäpper, I., van Gogh, M., Maaouni, T., Benhayoun, J., Ashikhmin, D., Lahmar, H., Sigal, M.: Collaborative innovation within the maritime sector: the path to grow back better. UNCTAD Transport and Trade Facilitation No. 89, Article No. 73. https://unctad.org/news/collaborative-innovation-within-maritime-sector-path-grow-back-better
[14] Raza, Z., Woxenius, J., Vural, C.A., Lind, M.: Digital transformation of maritime logistics: Exploring trends in the liner shipping segment. Computers in Industry. 145, 103811 (2023).
[15] Razmjooei, D., Alimohammadlou, M., Ranaei Kordshouli, H.A., Askarifar, K.: Industry 4.0 research in the maritime industry: a bibliometric analysis. WMU J Marit Affairs. 22, 385-416 (2023). https://doi.org/10.1007/s13437-022-00298-8
[16] Ritonga, R.A., Ahmadi, N., Kusumastanto, T., Suwandi, R., Hasriningtyas, S., Arafat, H., Soleh, A., Suwito, S.R.: Readiness Implementation of Smart Port in Indonesia. COJ (Coastal and Ocean Journal). 6(1), 9 – 23 (2022)
[17] Santoso, S., Nurhidayat, R., Mahmud, G., Ari, A.M.: Measuring the Total Logistics Costs at the Macro Level: A Study of Indonesia. Logistics, 5, 68 (2021)
[18] Tijan, E., Jovi, M., Aksentijevic, S., Pucihar, A.: Digital transformation in the maritime transport sector. Technological Forecasting & Social Change. 170, 120879 (2021)
[19] Wendler-Bosco, V., Nicholson, C.: Port disruption impact on the maritime supply chain: a literature review. Sustainable And Resilient Infrastructure. 5, 1-17 (2019). https://doi.org/10.1080/23789689.2019.1600961
[20] Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. Journal of Business Research, 122(November 2019), 889–901. https://doi.org/10.1016/j.jbusres.2019.09.022