STOCHASTIC FINANCIAL EVALUATION OF INTERMODAL TERMINAL DEVELOPMENT

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Abstract: *Intermodal terminals (IMTs) have significant importance in logistics networks whose development enables the implementation of intermodal transportation technologies and participation in international goods flows. This article analyzes the financial risks of investing into an IMT in Belgrade (Republic of Serbia). The scientific contribution of the article is in being the first to use a stochastic financial evaluation model for assessing the development of an IMT. The article analyzes the financial risk probability over real-world data, considering the stochastic nature of container flow volumes and the prices of logistics services. The risk probability, as an output result of the used simulation model, is derived from the probability distribution of three distinct financial parameters – net present value (NPV), internal rate of return (IRR), and the benefit-cost ratio (B/C). The results of the analysis indicate that the development of the IMT is financially justified, with relatively low investment risk.*

Keywords*: intermodal transportation, intermodal terminal, stochastic analysis, net present value, internal rate of return, benefit-cost ratio*

1. INTRODUCTION

In the countries of the European Union (EU), the growth rate of logistics industry, the key area that supports economic development, is higher than the average economic growth rate of those countries (EC 2009). The development of logistics systems is the key for achieving regional competitiveness, economic prosperity, and sustainable development (Tadić et al. 2021).

The growth of living standards and the individualization of customer demands caused the need for developing and managing efficient logistics systems. Furthermore, the ongoing global trend is to strive towards the reduction of road transportation involvement in the overall freight transport by a modal shift towards more eco-friendly transportation modes – such as rail and inland waterway transportation modes. Obviously, intermodal

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transportation stands out as a sustainable development direction of regional, European, and global logistics networks.

To ensure the sustainability of intermodal systems, it is necessary to develop appropriate infrastructure, whose key elements are intermodal terminals (IMTs) (Ližbetin 2019). Determining the location, subsystem structure, and the role of IMTs represent some fundamental problems that require attention while modelling intermodal networks (Caris et al. 2008) and their solving should be executed in the context of financial and economic assessment.

This article uses a stochastic financial evaluation model for assessing the development of an IMT in Belgrade. The analysis is performed through three different financial parameters – net present value (NPV), internal rate of return (IRR), and the benefit-cost ratio. By applying the simulation-analytical model the probability distributions of observed parameters are derived. Based on those distributions, the investment risk of the IMT is determined. The main contribution of this article is in being the first one to financially assess IMT development in a stochastic environment for real-world terminal development data.

The article is organized into five sections. The next section presents a short literature review of intermodal transportation, the funding of intermodal transportation projects, and the stochastic approach to solving problems in that area. Section 3 explains the stochastic approach used for the analysis. Section 4 presents the case study for which the financial assessment is performed. Section 5 presents the result analysis. At the end, the concluding section is presented.

2. LITERATURE REVIEW

Intermodal transportation represents the movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes (ECMT 2001). Positive effects that follow the application of intermodal transportation are reflected by the reduction of energy use, time, costs and negative environmental effects of transport. Obviously, intermodal transportation stands out as one of the key factors for achieving sustainable development.

In developed countries of the European Union (EU), intermodal transportation has an institutionalized character and clearly defined models for funding its development exist (Tadić et al. 2017). Having in mind that the majority of developed European intermodal networks are concentrated in its western parts, southern and southeastern Europe falls back greatly (Tadić et al. 2021). The integration of countries into the European logistics and transportation system, as well as in the realization of international goods flows, is not possible without the application of intermodal technologies.

IMTs, as one of the main subsystems of intermodal transportation, represent facilities where intermodal units' storage and transshipment between different transportation modes takes place. IMTs are vital nodes of every intermodal network and they stand out as important catalysts of regional economic development.

Logistics networks are systems composed of nodes and connections between those nodes. In general, the nodes of a logistics network represent the origins and final destinations of goods flows, and they can be facilities, warehouses, logistics centres, IMTs, ports, etc.

(Janic 2007). The links between network nodes are established with road or rail infrastructure, or via inland waterways. IMTs represent complex systems which can differ in their function, role, subsystems, users, applied technologies, etc. (Krstić 2019).

Regions that do not possess appropriate logistics infrastructure and which are not included in an intermodal network become uncompetitive in the logistics service market. The trade of these regions is penalized, which leads to the dislocation of goods and services into better-serviced regions (Monios 2015). Infrastructural investments are of vital importance for the development of logistics infrastructure and so for the economic activity of a state/country/region as well.

The development of IMTs is followed by high investments and long construction periods, as well as a low return rate of the investments. Having this in mind, it is obvious that individual engagement of the private sector in this area is rare. During the development of intermodal systems, large amounts of funding and subsidies are required before any profits begin to happen, therefore state intervention is required when developing intermodal networks (Wiegmans and Behdani 2017). High investments and potential investment risks stimulate public-private partnerships (PPP) in funding the projects of intermodal transportation.

PPP refers to different collaboration forms of public authorities and the private sector with the goal of funding, construction, restoration, management, and maintenance of infrastructure or providing services (EC 2004). The forming of PPP is a result of recognizing the gains from joining financial assets, knowledge, and skills with the goal of improving certain activities or services. Through PPP, the public and private sectors share costs, risks, responsibilities, and benefits (Ittmann 2017). The main motive for the private sector for joining a PPP for the projects of intermodal transportation is better opportunities for offering a wider set of logistics services and a larger profit, while the state gains modal shift (from road to rail/inland waterway modes) and stimulates regional sustainable development.

Defining an appropriate PPP model is a complex task when developing IMTs. The public sector has to define the partnership model in a way to minimize uncertainties and risks, but at the same time, to make it attractive for the private sector (Nguyen and Notteboom 2017). Defining a PPP represents a serious challenge for developing countries because they lack collaboration experience between the public and private sectors in the projects of intermodal transportation.

A large number of external factors that influence the realization of intermodal chains and their complexity give the problems of intermodal transportation stochastic traits, therefore simulation stands out as an appropriate tool for their solving (Crainic et al. 2018). In the existing literature, simulation has been used for solving various problems in the field of intermodal transportation, such as locating IMTs (Vidović et al. 2011), modelling intermodal networks (Yang et al. 2016), allocating resources in intermodal systems (Wang et al. 2017), container flow volumes prediction (Meng and Wang 2011), terminal capacity dimensioning (Özkan et al. 2016), etc.

The article (Tadić et al. 2020) conducts a financial analysis of developing an IMT in Belgrade but in a deterministic environment. It is concluded that the development of an IMT is financially justified, but the authors point out that analysis in a stochastic environment is necessary in order to determine the investment risks in such a project. The article has shown that the financial justification of developing an IMT is more sensitive to the changes in container flow volumes than to the changes in terminal service charges. The article (Raicu et al. 2012) analyzes different development scenarios of an IMT in Bucharest, where the scenarios differ in the terminal services.

This article uses a simulation model to determine the investment risks of an IMT in Belgrade from the aspect of three financial parameters – NPV, IRR, and B/C. In contrast with the article (Raicu et al. 2012) where only terminal service prices are a variable, this article considers also variable container flow volumes. Based on the container flow volumes and terminal service prices, the financial flows of the terminal are determined and so are the probability distributions of the observed parameters as well.

3. STOCHASTIC APPROACH IN THE FINANCIAL ANALYSIS OF AN IMT DEVELOPMENT

When designing logistics systems, stochastic factors that mostly have an impact on the system are demand characteristics which refer to the type, assortment, and the quantity of goods, demanded delivery time, the service itself, etc. It is not unusual for a logistics system to be unable to serve all the demands because of the lack of capacities or to have wasted capital due to underutilized capacities. These situations are mostly the consequence of inadequate understanding of factors that impact the development and exploitation of a logistics system.

In the context of intermodal transportation, container flows volume on a certain relation is a probabilistic variable. Despite that a trend line for container throughput could be identified and predicted, it is common for the volumes to deviate significantly from the predicted values. Considering the complexity of all the factors that influence these deviations, there is no model that could precisely determine the container flow nature over a longer time period. Furthermore, logistics service prices are also a variable category. Service prices of an IMT are tightly bound to the global and local state of the economy, and political circumstances, but also to the competition in the logistics services market.

The traditional approach to calculating financial parameters does not take into account the stochastic nature of all the factors that impact their value. Therefore, a simulation is recognized as a suitable method for calculating the financial parameters' value in a stochastic environment. The stochastic approach to determining financial parameter value enables the decision-maker better insights into the investment risks of a project (Shaffie and Jaaman 2016). In stochastic approaches for determining financial parameters, with probability distributions as input data, the output results (financial parameters) are also in the form of probability distributions (Tziralis et al. 2009). Three financial parameters are considered in this article – NPV, IRR, and B/C.

NPV is one of the standardized project evaluation and selection parameters and it takes into consideration the time value of assets. The calculation of NPV includes the discount of all future asset inflows and outflows. A project will be accepted if the NPV is positive, or refused if NPV is negative. IRR represents the discount rate for which the NPV of the project equals zero. When the value of IRR is greater than the actual interest rate, the observed project is financially acceptable. By comparing the discounted values of benefits and costs the benefit/cost ratio (B/C) is calculated. In other words, B/C represents the relation of present values of benefits and costs. An investment project is accepted if the value of B/C equals/is greater than 1 (Petrović-Vujačić et al. 2019).

Considering the stochastic nature of all the factors that influence the costs and profits of an IMT, the input parameters and data are probability functions and therefore NPV, IRR, and B/C, as output parameters, are in the shape of probability distributions as well. Based on the probability distributions of the output parameters, the financial risks of the project can be easily determined.

For the financial evaluation of the IMT development a simulation model, based on the article (Zaman et al. 2017), is developed. The model simulates the stochastic nature of all input parameters and determines the probability distributions for NSV, IRR, and B/C. From these probability distributions, IMT development investment risks can be determined. From the aspect of NPV, the risk is represented as the probability that the project NPV value would be negative or equal to zero, while from the aspect of IRR, the risk is represented as the probability that the IRR value would be lesser than the project discount rate. According to B/C, the risk is represented as the probability that the B/C would take values below 1.

4. IMT IN BELGRADE AND INPUT DATA

The IMT in Belgrade (Batajnica, 15 km away from the city centre) is in the focus of this article analysis. The analysis is performed in the context of the data from (Tadić et al. 2020, EC 2012) but in a stochastic environment. The predicted terminal container flow throughput volumes are presented in Table 1.

Table 1. Predicted container flow volume over time (Tadić et al. 2020, EC 2012)

Year	Container throughput (TEUs)	Growth (%)	Year	Container throughput (TEUs)	Growth (%)
2013	0	0	*2028*	54880	2.3
2014	3200	0	*2029*	61040	11.2
2015	15960	398.8	*2030*	65520	7.3
2016	21000	31.6	*2031*	70611	7.8
2017	27300	30	*2032*	74055	4.9
2018	30660	12.3	*2033*	77499	4.7
2019	33460	9.1	*2034*	80943	4.4
2020	34580	3.3	*2035*	84387	4.3
2021	38080	10.1	*2036*	87831	4.1
2022	44240	16.2	*2037*	91275	3.9
2023	46480	5.1	*2038*	94719	3.8
2024	47320	1.8	*2039*	98163	3.6
2025	51100	8	*2040*	101607	3.5
2026	53620	4.9	*2041*	105051	3.4
2027	53620	0	*2042*	108495	3.3

When designing any logistics centre, a wrong assumption regarding the goods flows throughput volumes can lead to catastrophic consequences. The acceptance of any logistics-related project has to be accompanied by appropriate risk and sensitivity analyses. Considering the stochastic nature of goods flows through time, project financial analysis should also include possible parameter deviations from the predicted values. In this article, it is assumed that the expert predictions of container flow volumes would vary between -50% and +50%. Three container flow volumes deviation scenarios are considered: pessimistic, realistic, and optimistic (Figure 1). For every scenario, a probability distribution of the flow volume deviation is defined. The occurrence probability for the realistic scenario is 0.4, while the occurrence probability for the other two scenarios is 0.3 for both.

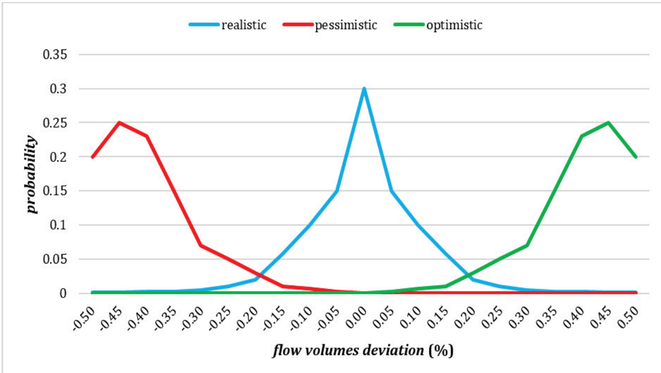

Figure 1. Container flows volume deviation scenarios

The development of the IMT in Belgrade is planned to be executed through two operational phases (EC 2012). Both phases refer to specific type of construction works and require specific investments. Since the construction and development expenses of an IMT are extremely high, it is assumed that the private investor would take loans. All the data regarding the development phases, their dynamics, required investments, loan repayment, and other assumptions are taken from (EC 2012) and are explained in detail in the article (Tadić et al. 2020).

Table 2. IMT services prices (EC 2012)

<table>
<tr><th>Service</th><th colspan="3">Price</th><th>Service</th><th colspan="3">Price</th></tr>
<tr><td>Manipulation with ITUs</td><td colspan="3">39 €/manipulation</td><td rowspan="2">Road transportation planning</td><td>In the boundaries of the logistics zone</td><td>On the territory of Belgrade</td><td>Outside of Belgrade</td></tr>
<tr><td rowspan="4">ITU storage</td><td>First three days for importing containers and one day for exporting containers is this service free of charge</td><td>For containers</td><td>For EITUs</td><td>80 €</td><td>144 €</td><td>190 €</td></tr>
<tr><td>Storage for the next 5 days</td><td>16 €/day</td><td>29 €/day</td><td rowspan="2">Parking</td><td>First two hours</td><td colspan="2">After the first two hours</td></tr>
<tr><td>Storage for the next 2 days</td><td>34 €/day</td><td>68 €/day</td><td>Free of charge</td><td colspan="2">7.5 €/h</td></tr>
<tr><td>Storage for the next 2 days</td><td>57 €/day</td><td>99 €/day</td><td>Cancelling fees</td><td colspan="3">85 €/cancellation</td></tr>
<tr><td>Specialised ITU storage</td><td colspan="3">Additional 30% on the prices for standard ITUs</td><td>Container inspection fees</td><td colspan="3">17 €/container</td></tr>
</table>

Terminal service prices directly impact the amount of profits during its exploitation cycle. Having in mind that all the factors that dictate terminal service prices are variable, it is assumed that the prices may vary over time as well. Basic terminal service prices are shown in Table 2. Inadequate assumption of future terminal service prices might form an unrealistic picture of expected profits. In this article, the terminal service prices might vary from the basic values in a predefined range. The probability distribution of terminal service prices deviation is presented in Figure 2.

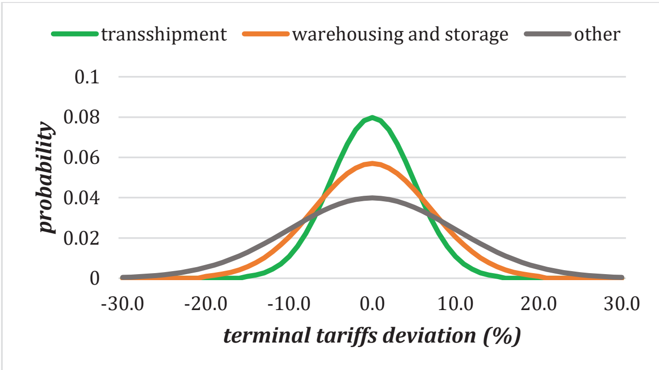

Figure 2. Probability distribution of possible terminal service prices deviation

Annual IMT expenses can be divided into fixed and variable expenses (Table 3). All terminal exploitation profits and expenses are evaluated according to real-life and the (EC 2012) project data.

Table 3. IMT fixed and variable expenses (Tadić et al. 2020; EC 2012)

Fixed expenses	*Expenses*	*Variable expenses*	*Expenses*
Energy, telecommunications, Internet	30000 €/year	*Personnel salaries and expenses*	17155 €/employee
Office equipment	22500 €/year	*Manager salaries and expenses*	32740 €/employee
Service insurance and taxes	57500 €/year	*Annual training, control and inspection costs*	10 % of employee costs
Fixed maintenance costs	333000 €/year	*ITU manipulation electricity expenses*	1.45 €/ITU
Freight village developer fees	160000 €/year	*Road transportation planning expenses*	100 €/truck

5. RESULT ANALYSIS

According to the simulation model, the NPV values range between -7 and 18 million € for a period of 30 years (Figure 3). The most probable NPV (with a probability of 0.12) is 5 million €. The investment risk according to NPV is 11.3%.

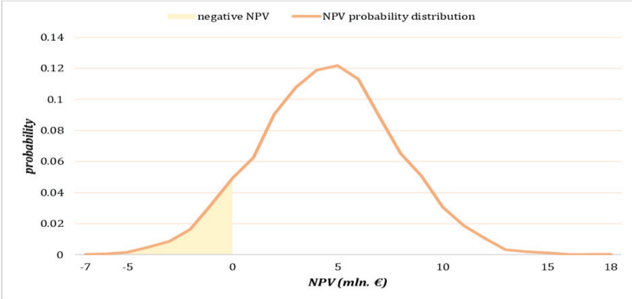

Figure 3. NPV probability distribution

According to IRR, the results differ from those of NPV, but from the perspective of investment risks, they are the same since IRR and NPV are mathematically complementary parameters. The values of IRR are in the range between 1% and 18%, where the most probable value is 8% (with a probability of 0.22). As is the case with NPV, the investment risk is 11.3% (Figure 4).

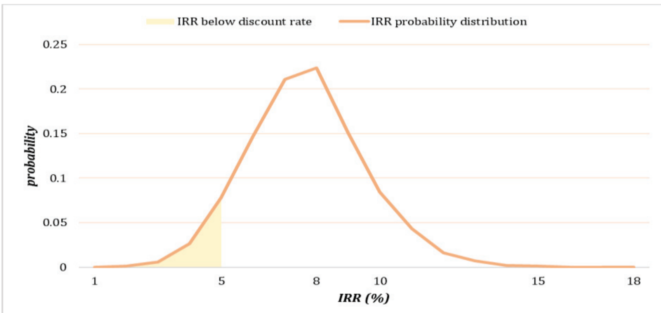

Figure 4. IRR probability distribution

The values of B/C are in the range between 0.9 and 1.3, while the most probable value is 1.1 (with a probability of 0.39). According to the probability distribution of B/C, the investment risk is 6.81% (Figure 5).

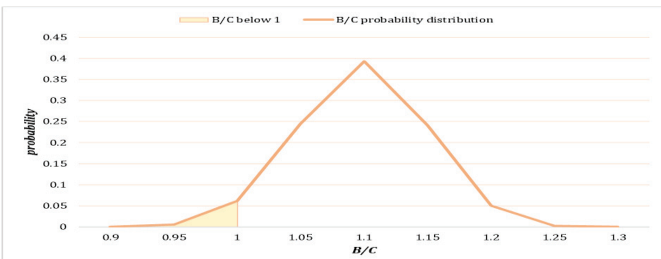

Figure 5. B/C probability distribution

6. CONCLUSION

This article presented a stochastic financial analysis of an IMT in Belgrade. The analysis is performed in the context of three parameters – NPV, IRR, and B/C. A stochastic approach is applied in determining the values of the parameters. Considering the dynamic and stochastic nature of the input parameters and data, the output results are in the shape of probability distributions.

The analysis of the results shows that the development of an IMT in Belgrade is financially justified. The investment risk, according to NPV and IRR is 11.3%, while according to B/C, the investment risk is 6.81%. The most probable NPV is 5 million €, while the most probable IRR is 8%. The value of B/C with the greatest probability is 1.1.

Considering the results, it can be stated that the development of an IMT in Belgrade is financially justified, with relatively low investment risk. The direction of future research could be in the analysis of the effects that the development of an intermodal system would result in, especially on the economic growth of a country/region. Of course, that should be preceded by a more detailed analysis of the required number of terminals, their location, structure, etc. One of the directions could also be in the analysis of intermodal technologies that justify its system development and application in developing countries and regions.

REFERENCES

[1] EC - European Commission. (2004). A cleaner, greener Europe. LIFE and the European Union waste policy. Publications Office of the European Union, Luxembourg.
[2] EC – European Comission. (2009). A sustainable future for transport towards an integrated, technology-led and user friendly system. Publications Office of the European Union, Luxembourg.
[3] EC Delegation to the Republic of Serbia. 2012. Facilitating intermodal transport in Serbia, Republic of Serbia, 2010-2012.
[4] ECMT - European Conference of Ministers of Transport. (2001). Terminology on combined transport. Available online http://www.unece.org/fileadmin/DAM/trans/wp24/documents/term.pdf, (New York and Geneva, 2001). Last accessed on 11.2.2021.
[5] Caris, A., Macharis, C., Janssens, G.K. (2008). Planning problems in intermodal freight transport: Accomplishments and prospects. Transportation Planning and Technology, 31(3): 277-302.
[6] Crainic, T.G., Perboli, G., Rosano, M. (2018). Simulation of intermodal freight transportation systems: a taxonomy. European Journal of Operational Research, 270(2), 401-418.
[7] Ittmann, W. (2017). Private-public partnerships: A mechanism for freight transport infrastructure delivery. Journal of Transport and Supply Chain Management, 11, 1-13.
[8] Janic, M. (2007). Modelling the full costs of an intermodal and road freight transport network. Transportation Research Part D, 12, 33-44.
[9] Krstić, M. (2019). Modelling the structure of intermodal terminals. University of Belgrade, Faculty of Transport and Traffic Engineering, Belgrade, Serbia. Doctoral dissertation.
[10] Ližbetin, J. (2019). Methodology for determining the location of intermodal transport terminals for the development of sustainable transport systems: A case study from Slovakia. Sustainability, 11(5): 1230.

[11] Meng, Q., Wang, S. (2011). Intermodal container flow simulation model and its applications. Transportation Research Record: Journal of the Transportation Research Board, 2224(1), 35-41.

[12] Monios, J. (2015). Intermodal transport as a regional development strategy: The case of Italian freight villages. Growth and Change 47(3), 363-377.

[13] Nguyen, L., Notteboom, T. (2017). Public-private partnership model selection for dry port development: an application to Vietnam. World Review of Intermodal Transportation Research, 6(3), 229-250.

[14] Özkan, E.D., Nas, D., Güler, N. (2016). Capacity analysis of Ro-Ro terminals by using simulation modeling method. The Asian Journal of Shipping and Logistics, 32(3), 139-147.

[15] Petrović-Vujačić, J., Kaplanović, S., Miljković, M. (2019). Engineering economy in transport and telecommunications (In Serbian), University of Belgrade, Faculty of Transport and Traffic Engineering, Belgrade, Serbia.

[16] Raicu, R., Raicu, S., Popa, M., Costescu, D. (2012). On the evaluation of urban logistics intermodal terminal projects. Procedia – Social and Behavioral Sciences, 39, 726-738.

[17] Shaffie, S.S., Jaaman, S.H. (2016). Monte Carlo on net present value for capital investment in Malaysia. Procedia – Social and Behavioral Sciences, 219, 688-693.

[18] Tadić, S., Zečević, S., Milenković, D. (2017). Intermodal transport treatment in developed and developing countries. Tehnika, 67(6), 897-902.

[19] Tadić, S., Petrović-Vujačić, J., Kovač, M. (2020). Financial analysis of the intermodal terminal in Belgrade. Tehnika, 70(6), 782-789.

[20] Tadić, S., Kovač, M., Krstić, M., Roso, V., Brnjac, N. (2021). The selection of intermodal transport system scenarios in the function of Southeastern Europe regional development. Sustainability, 13(10), 5590.

[21] Tziralis, G., Kirytopoulos, K., Rentizelas, A., Tatsiopoulos, I.P. (2009). Holistic investment assessment: Optimization, risk appraisal and decision making. Managerial and Decision Economics, 30(6), 393-403.

[22] Vidović, M., Zečević, S., Kilibarda, M., Vlajić, J., Bjelić, N., Tadić, S. (2011). The p-hub model with hub-catchment areas, existing hubs, and simulation: A case study of Serbian intermodal terminals. Networks and Spatial Economics, 11(2), 295-314.

[23] Wang, H., Wang, X., Zhang, X. (2017). Dynamic resource allocation for intermodal freight transportation with network effects: Approximation and algorithms. Transportation Research Part B: Methodological, 99, 83-112.

[24] Wiegmans, B., Behdani, B. (2017). A review and analysis of the investment in, and cost structure of intermodal rail terminals. Transport Reviews 38(1), 1-19.

[25] Yang, K., Yang, L., Gao, Z. (2016). Planning and optimization of intermodal hub-and-spoke network under mixed uncertainty. Transportation Research Part E: Logistics and Transportation Review, 95, 248-266.

[26] Zaman, M.B., Priyanta, D., Trisilo, F. (2017). Risk assessment in financial feasibility of tanker project using Monte Carlo simulation. International Journal of Marine engineering Innovation and Research, 1(4), 303-316.