Scientific Journal of Silesian University of Technology. Series Transport
Zeszyty Naukowe Politechniki Śląskiej. Seria Transport

Volume 103 **2019**

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: https://doi.org/10.20858/sjsutst.2019.103.12

Journal homepage: http://sjsutst.polsl.pl

Article citation information:
Scherbina, O., Drozhzhyn, O., Yatsenko, O., Shybaev, O. Cooperation forms between participants of the inland waterways cargo delivery: A case study of the Dnieper region. *Scientific Journal of Silesian University of Technology. Series Transport*. 2019, **103**, 155-166. ISSN: 0209-3324. DOI: https://doi.org/10.20858/sjsutst.2019.103.12.

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COOPERATION FORMS BETWEEN PARTICIPANTS OF THE INLAND WATERWAYS CARGO DELIVERY: A CASE STUDY OF THE DNIEPER REGION

Summary. The society's main trend for globalisation requires the restructuring of the global transport system as a whole. The 'Dnieper region' is no exception, as it needs changes in its practice of organising and managing its process of cargo delivery in accordance with the current trends. This paper considered the main solution directions of this problem in the aspect of 'container on barge system' transportation in accordance with the potential of the region. Based on international experience, the competitiveness of the container on barge system can be ensured by applying the different forms of cooperation between the business-players. In the case of horizontal cooperation, it's raising the problem of distribution of structural elements of the container on barge system during the container-flows adoption. So, the paper proposed the mathematical decision to

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maximise the use of the linear ship's characteristics by the barge's loading capacity and by the tug's engine power.

Keywords: cooperation, inland waterways, container on barge system, container transportation

1. INTRODUCTION

Presently, the transport potential of the Dnieper-river region and its importance in international transportation, and in particular in the transport system of Ukraine, is yet to be fully investigated.

Dnieper is an international inland waterway (IWW) of 'E category' (according to European Agreement on Main Inland Waterways of International Importance, a United Nations treaty adopted by the UNECE Inland Transport Committee in 1996), which is open to foreign-flag ships. This provides the background to connect with the Danube, Don and Volga rivers to access the Black Sea, Azov Sea, Mediterranean, Caspian and Baltic seas along the TRACECA corridor.

One of the advantages of the IWW transport of the Dnieper region is the concentration of the industrial and agricultural sectors (that is, origin and destination of cargo flows), which serves as a basis for the bulk and container cargoes transportation. Due to the global development of containerisation, IWW transportation should also be considered as an element of transport systems involved in the global container market. The perspective way for the development of IWW transport is the 'containers in barge' (COB) system, that is spreading in the EU-countries and the USA. However, for the implementation of COB, a number of conditions are required, including:

– significant volumes of container flows between the sea and river ports of a certain regional market,
– reliability and regularity of transportation,
– application of modern transport, cargo handling, navigation and information technologies in the management and regulation of transport processes.

Thus, the efficiency of business activity depends on the management system of the cargo delivery process, which needs to be reinterpreted.

2. LITERATURE REVIEW AND PROBLEM STATEMENT

The issues of shipping companies partnership and cooperation, which are implemented in a variety of organisational, legal, technological, financial, business and commercial forms are well-considered by a wide range of scientists, especially recently, when globalisation and integration processes are involved in world production activities, including transportation.

The global shipping management system offers various combined business-plans based on the practice of the best transport elements (such as port, fleet, agents, forwarders, etc.) in use. It takes into account, the realities of today's state of environment, the business basis and the interests of the market players. The system is aimed at obtaining the maximum economic and social outcomes from the lowest transport with minimal risks to the natural environment.

An example of such global systems is the creation of the corporative fleet of British Petroleum Corp., the corporative ore-specialised Port Hedland, Western Australia.

In the container shipping market, the result of mergers and acquisitions has been observed in recent years with the formation of three global shipping alliances:
1) ONE (Hapag-Lloyd, UASC, Yang Ming).
2) OCEAN Alliance (CMA CGM, COSCO, Evergreen, OOCL).
3) 2M + HMM (MSC, Maersk, Hyundai M. M.) [1-3].

It should be noted that the theory of integration processes in the container market preceding these global changes have been well-studied in analytical and review papers [4-7] before it came to light.

Taking into account the considerable scientific contribution of papers from the last generation [8-11] concerning the forms and nature of cooperation in the global container market, more attention should be given to the integration processes that take place in the segment of container transportation on IWW on the 'horizontal', and 'vertical' levels.

This circumstance is logically explained by a minor number of IWW ports, where container transportation accounts for a significant share of cargo turnover. In EU countries, for example, COB system is well developed on the basis of container flows on the Antwerp − Rotterdam range [12-14]. The experience of container transportation on barges through Le Havre and Marseilles ports is presented in [15]. A comparative analysis of the similarities and differences between the spatial and functional development of IWW container transport networks on the Yangtze River and the Rhine is presented in [16]. A pre-review of the possibilities of applying the COB-technology on the Ohio River in the US was also published [17].

Generally, the published papers on cooperation forms, partnership and integration processes that occur during container transportation can be divided into the following groups: works that are studying strategic partnership (alliances) [1, 2, 3, 4, 5, 11, 27], geographically contextual papers [10, 13, 14, 15, 17, 18, 24, 25, 26], articles devoted to pricing [8, 9], overviews and descriptive articles [5,6,7] and those that offer formalised solutions: factor analysis of empirical data, Venn diagram [2], the Multiple-criteria decision-making (MCDM) [3], the Game theory [10], Mathematical logic on the basis of binary variables [11], tools and software of discrete event simulation model, based on queuing theory [14].

Given the successful experience of implementing the COB technology in Western Europe and, on the Ukrainian part of the international IWW [18-19], it can be assumed that the presented article will be useful in the context of the Dnieper region.

2.1. Purpose and objectives

The research aimed at determining the main cooperation and integration directions of the operation of the TBV (tug-barge system) in the Dnieper region, in accordance with international transportation practice. To achieve this purpose, the following tasks were solved:
1) by analysing the shipping company's co-operation, operating by the TBV.
2) by defining the size of the TBV, transporting containers and operation by the 'horizontal co-operation' form.

2.2. Data and methodology

This paper is based on issued statistical reviews. Methodologically, inter-scientific tools was used: Inductive and deductive reasoning, transport systems theory, methods and tools for system analysis (Linear Programming). EXCEL Solver add-in was applied for the experimental solution.

3. THE MANAGEMENT SYSTEM REORGANIZATION

3.1. Statement of the task of reorganization of the system of management of companies' activities in the work of the tug-barge vessel in the Dnieper region

Every table should have its own title. The horizontal test direction is preferred. Using vertical text direction is only acceptable for large tables. In this case, the table will be positioned on a separate page.

Ukraine still practices the Soviet management system, operating separate business-companies for the service of certain stages of the cargo movement (shipping companies, ports, intermediary and service companies). However, since 2009, the agricultural company 'Nibulon' (Ukrainian, Hungry, British investments) has overcome the stereotypes by creating a shipping company for the transportation of grains. However, the practice of containers transportation is still nonexistent.

Despite the advantages of intermodal container transportation for the Dnieper region and its prospects for the development of Ukraine and countries admitted to the Transport Corridor Europe-Caucasus-Asia (TRACECA), there are still a number of obstacles and disadvantages [20]:

1) Geographical characteristics of the Dnieper River (sinuosity, limited navigation period, sluices).
2) IWW decline, which occurs due to the lack of controlled funding for its own maintenance and its technical and navigational equipment, as well as cargo terminals and ports located alongside them.
3) Lack of solvency of most operating river shipping companies.
4) Lost centralised management and, in particular, transportation planning in interregional and international transport connections with the participation of both water and related modes of transport.
5) Great competition from rail and road services, which are able to provide a "door" service format, both in internal and external economic relations.

Due to this and other factors, the cargo turnover of the Dnieper river ports barely reaches 4 million tons per year, compared to 70 million in the Soviet times.

The design development assumes that the shortcomings of the operation of the transport system of the Dnieper region, identified during the analysis of studies, are partly reduced by reorganising the carriers' structure and refinancing their activities in particular due to:

1) State support of carriers:

- implementation of a mechanism for financing the proper maintenance of the Dnieper river and adjacent small rivers using hydropower,
- restoration of the regional principle and infrastructure providing logistic services for cargo owners, motivating them to switch loads for mixed land-water transportation,
- definition and state support for containerised transportation in international land-water cargoes, oriented towards the needs of foreign trade for Ukraine and transit of the adjacent basins of the Wisla - Baltika, Black and Mediterranean seas of the other countries.

2) Implementation of new formats of public-private partnership and the development of the communal sector of the economy, including the activities of companies-operators of intermodal service. These companies are open to attracting funds from interested cargo owners and regional authorities or local governments as investment resources for the restoration of navigation on the IWW of Ukraine and its partner countries. Such innovation will enable:

- the capitalisation of resources of territorial communities and individual cargo owners,

- increase the level of controllability on their part in the planning and implementation of intermodal transportation through the use of geographic information systems,
- intensify the influence of territorial communities on the implementation of investment programs for the recovery of the fleet and coastal water transport infrastructure.

There is a need to strengthen the interaction between the public and private sectors, public authorities and local self-government bodies, and the introduction of decentralisation.

3) State support of freight traffic: Determination of gravity zones of cargo flows to river terminals in order to optimise transportation schemes will enable:

- active influence on the structure of gross expenses of the cargo owner in intermodal transportation,
- the forming of an open system of competitive tariffs for intermodal transportation and to make a transparent distribution of payments for transportation between all participants in their implementation,
- rationalised investment of funds in the infrastructure of intermodal transportation (terminals, cargo equipment, navigation facilities etc.),
- the reduction of the load on land transport in critical zones and in peak seasons (grains, fertilizers etc.).

Thus, one way of restoring national shipping is to create a joint-stock company based on a public-private partnership.

Areas of operation for such a company under the technical conditions of inland waterways of Ukraine should determine the following areas:

- Upper Dnieper with access to the Belarusian and Polish IWW,
- Middle Dnieper with access to the industrial cargo-producing regions of Ukraine,
- Lower Dnieper River with access to the seaports of the Dnieper-Bug estuary, first of all, Ochakov,
- Southern Bug.

The division of the IWW into areas (traction shoulders) takes place on the principle of equivalent operating conditions of the vessels.

Thus, the scheme of transportation of containers of the IWW has the following options:

1) transportation between river ports of one district;
2) transportation between river ports of different regions;
3) transportation between river ports of one or several regions with access to sea ports.

The tendencies of development of world practice of transportation of containers of the IWW include the overloading of sea ports by one of the variants "ship-warehouse", "ship-ship", "ship-raid transshipment complex".

An analysis of the practice has shown that container transport by inland water transport is carried out by self-propelled dry cargo vehicles, coupled vessel modules, tug-barge system and self-propelled barges.

In general, for the purpose of carrying out container transportation and ensuring the reloading process, such a company must include the following technical means:

- river and mixed river-sea swimming barges-platforms for transportation of containers, with technical and operational characteristics corresponding to defined areas of use,
- river and mixed river-sea swimming tugs for working with such barges,

- self-propelled river barges for navigation through all identified areas of service without overload,
- marine container vessels for feeder service to large sea container hubs of the Black Sea,
- floating container reloaders,
- floating platforms, berths for overloading of containers under the sloping scheme,
- terminal reloaders and container transporters,
- own means of land transport of containers with special needs of an intermodal service (the same refrigerated containers, or super-heavy containers and containers of increased size),
- means and equipment for loading/unloading containers, including container capacities for bulk and liquid cargoes,
- a small private park of containers of the most requested clients of the parameters or containers for the transportation of unique cargoes.

Logistic schemes for operation by such a company to provide services for an intermodal container service should be handled in conjunction with:

- large ocean container carriers according to the schedule of traffic, tariffs for transportation and terminal maintenance in large container hubs, including other conditions of transshipment;
- regional logistic centres to establish a balance between the arrival in the region of the customs clearance of containers with imported goods and the dispatching of containers with export goods to be discharged from the regions to large sea container hubs. Balance will determine the possibility of using the released containers for the transportation of new types of cargo, or the need to bring empty containers to the region for loading;
- known producers or consumers of goods in mass quantities (large trading networks, powerful exporters and importers, etc.) in the regions;
- established numerical parameters (the forecast of traffic, traffic in the areas of gravity freight traffic).

Potential users and co-owners of such a company should identify global container service providers. This is important as their computer information resources are effective tools in solving the problem of quality improvement of container logistic service management.

Information and technological parameters with the integration of computer and network resources within the company should be based on modern ideas about open network information resources, methods of their modelling, database design, selection methods, analysis and processes of operating information about transport service.

Beneficiaries of such an enterprise have / may be:

- customers of intermodal services (producers, consumers of goods, commodity traders, enterprises of the state reserve of goods),
- providers of individual components of the intermodal service (port stevedore, warehouse operators, surveyors, others),
- providers of individual components of information service (equipment, software products, content of open databases and services),
- investors in the transport sector (banks, funds, leasing companies),
- shareholders (legal entities of private and public law, individuals, both Ukrainian and other states).

Based on world practice, such cooperation is vertical. However, at the same time, horizontal co-operation may also take place. A visual representation of the differences is presented in Fig. 1

Thus, any of the partner companies can integrate vertically and (or) horizontally, depending on the services they operate as their primary business.

Transport company types	Cooperation options				
	1	2	3	4	5
	Number of participants				
	2 (min)	3	4	5	N (max)
Shipping company	+	+	+	+	+
Barge owners	+	+	+	+	+
Ship agents		+	+	+	+
Stevedore company			+	+	+
Port forwarders				+	+
Others					+

a

		Transport company types	Number of participants				
			2 (min)	3	4	…	N (max)
Cooperation options	1	Shipping company	+	+	+	+	+
	2	Barge owners	+	+	+	+	
	3	Ship agents	+	+	+		
	4	Stevedore company	+	+			
	5	Port forwarder	+				
	6	Others	+				

b

Fig. 1. Options for vertical and horizontal co-operation of transport and service companies: *a* - vertical integration; *b* - horizontal integration

As observed, tug-barge transportations are promising on the IWW, the effectiveness of which, primarily depends on the organisation of the work of tug-barge vessels, which is the solution of many problems. In the operation of such societies with the participation of several carriers in their horizontal co-operation, there is the question of the distribution of structural elements of the TBV during the adopting of container traffic.

3.2. The task of determining the configuration of a tug-barge vessel in vertical integration

This speciality of TBV as a possibility to separate the traction and cargo components, allows the vessel to use a different number of barges, depending on the conditions of the flight. Therefore, the task of distribution of ships is somewhat complicated.

At the first phase, this task requires solving the problem of determining the configuration of the TBV [21], which is solved by the following mathematical model (1-6).

$$Z = \sum_{j=1}^{J} x_{jz\ell} \cdot N_{jz\ell}^{TEU} \cdot q^{TEU} \cdot Y_{jz\ell} \to max \quad ; \qquad (1)$$

$$\sum_{j=1}^{J} x_{jz\ell} \cdot N_{jz\ell}^{TEU} \cdot q^{TEU} \cdot Y_{jz\ell} \le Дч_{max}^{z\ell} \qquad (j=\overline{1,J};\ z=\overline{1,Z};\ \ell=\overline{1,L}) \quad ; \qquad (2)$$

$$\sum_{z=1}^{Z}\sum_{\ell=1}^{L} x_{jz\ell} \le Nj \qquad (j=\overline{1,J}); \qquad (3)$$

$$Y_{jz\ell} = \{0,1\} \qquad (j=\overline{1,J};\ z=\overline{1,Z};\ \ell=\overline{1,L}); \qquad (4)$$

$$x_{jz\ell} = 1,2,...P \qquad (j=\overline{1,J};\ z=\overline{1,Z};\ \ell=\overline{1,L}); \qquad (5)$$

$$x_{jz\ell} \ge 0 \qquad (j=\overline{1,J};\ z=\overline{1,Z};\ \ell=\overline{1,L}), \qquad (6)$$

where $x_{jz\ell}$ - the number of barges of type j, which are part of the TBV type z and operate on the scheme ℓ; $N_{jz\ell}^{TEU}$ - container capacity of a barges when the container is loaded 14 tons; q^{TEU} - the estimated load of the container is 14 tons; $Y_{jz\ell}$ - control parameter defining TEU transportation on the scheme ℓ barges of type j that are part of the TBV type z ($Y_{jz\ell}$=1 if barge type j is intended for carriage TEU in the circuit ℓ in the TBV type z (that is, identical destination of barges, their area of navigation and linear parameters, as well as coupling device allows you to work as a couple type λ and $Y_{jz\ell}$=0, otherwise); $Дч_{max}^{z\ell}$ - maximum allowable load capacity of type TBV with work on the scheme ℓ; Nj - the existing barge type j, which takes into account the fate of the company's participation in the chosen form of cooperation.

$$Дч_{max}^{z\ell} = min\left\{Дч_{p}^{z} max_{i}, Дч\ max_{\ell}\right\} \quad (i=\overline{1,I};\ z=\overline{1,Z};\ \ell=\overline{1,L}) . \qquad (8)$$

where $Дч_{p}^{z} max_{i}$ - the maximum registered load-carrying capacity of the TBV of type z when working with a type i tow; $Дч\ max_{\ell}$ - the maximum permissible load carrying capacity of the TBV, based on the restrictions on the scheme ℓ [22].

Limitation Description:

(1)?

(2) - the total load of type TBV consists of barge type j, carrying the load r, cannot exceed the maximum permissible load capacity in the scheme ℓ.

(3) - the total number of barges of type j in the composition of all TBV should not exceed the existing fleet for barges of the suitable type.

(4) - the parameter defining the transportation in the scheme ℓ of goods r on barge type j, which is part of the TBV type z, denotes the duality of the variables, that is, only accepts values 0 and 1.

(5) - condition of integer variables.

(6) the condition of the inseparability of variables.

In the presence of limitation on the number of barges in the type of TBV type ***z*** in the scheme ***ℓ*** into the model, the next limitation is introduced:

$$\sum_{j=1}^{J} x_{jz\ell} \le N_{max\,j}^{\ell} \qquad (z = \overline{1, Z}; \ell = \overline{1, L}), \tag{9}$$

where $N_{max\,j}^{\ell}$ - the maximum number of barges of type ***j*** coupled in the TBV in the scheme ***ℓ*** depending on the area of navigation.

Model (1) - (7) is valid for the distribution of barges for operation on the single scheme. In the distribution of the existing barges for work in the TBV type ***z*** for several schemes of work ***ℓ***, the model introduces a limit (10):

$$\sum_{\ell=n_\ell+1}^{L} \sum_{j=1}^{J} x_{jz\ell} \le N_j - \sum_{\ell=1}^{n_\ell} \sum_{j=1}^{J} n_j^{z\ell} \qquad (z = \overline{1, Z}; \ell = \overline{1, L}), \tag{10}$$

where n_ℓ - the number of schemes considered; $n_j^{z\ell}$ - the number of barges of type ***j*** in the type of TBV type ***z*** work on the scheme ***ℓ*** for container transportation.

3.3. Experimental results of the solution of the problem of determining the configuration of the tug-barges vessels

Output data and results of the calculation of the mathematical model (1-6) are presented in Table. 1

Tab. 1

Output data and results of calculations

Barge *J*	Nj	$N_{jz\ell}^{TEU}$	q^{TEU}	$Y_{jz\ell}$		$Дч_{max}^{z\ell}$		$x_{jz\ell}$	
				ℓ=1	ℓ=2	ℓ=1	ℓ=2	ℓ=1	ℓ=2
1	8	50	14	1	1	6200	3200	8	0
2	5	20	14	1	1	6200	3200	5	0
3	3	40	14	1	1	6200	3200	3	0

The search solution options and the report on the solution results in EXCEL are shown in Fig. 2.

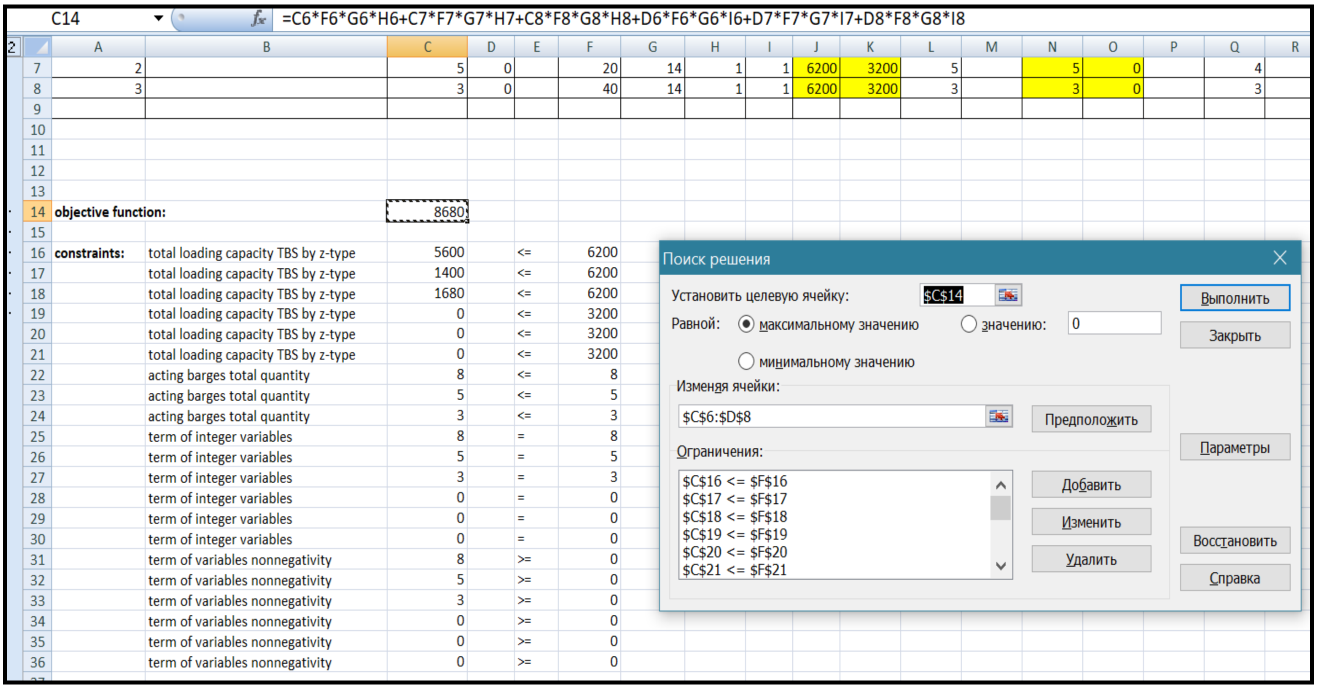

Fig. 2. Decision search options

4. CONCLUSIONS

The demonstrated researches establish the basic forms of cooperation of the participants of the transport process during the carriage of goods by tag and barges vessels on the inland waterway of Ukraine, as well as the conditions for their implementation.

Adjustment of the operation of shipping companies within the framework of horizontal cooperation requires the decision of a large number of tasks, including the distribution of vessels. Given that barges within the TBV may belong to different shipowners and their number as a variable depends on direct and indirect factors [21], then the task of determining the size of the TBV when transporting containers becomes complicated. The decision of the mathematical model (1-6) ensures maximum use of both the linear characteristics of the ship's way for the load capacity and the power of the engine. In addition, the model limits the total number of required vessels (barges type j), the existing fleet composition, taking into account its quantitative changes due to the resection from the fleet of shipowners and replenishment. In the model, the membership of barges to a company is counted by the index j. Conclusively, the total number of barges takes into account the lot of the company's participation in the chosen form of cooperation.

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Received 13.01.2019; accepted in revised form 28.05.2019