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Methodological Problems of Modern Transportation Logistics

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ABSTRACT: The terminology and conceptual apparatus of modern logistics as a scientific discipline is far from being shaped. Researches and developers of legislative and norm-setting documents are obliged to use their own or barrowed terminology, in both case not shared ubiquitously. Consequently, the interpretations even of basic concepts differ significantly. In particular, there exists an academic and practical point of view that refuse the right for existence of the term "transportation logistics". This clause is explained by the proclaimed omnipresence and universality of logistics, which has in its operational glossary the term "transportation", treated as a local, subordinated and thus secondary function. This paper tries to set a decisive rule to distinguish between general logistics and transportation logistics, arguing that these two disciplines are well separated by the objects and methodology, knowledge and activities. In transportation logistics defined this way the authors examine two principal components of the transportation processes, storage (warehousing) and movement (shipping). This consideration lead to conclusions that the classical mathematical toolkit is not fitted for the design and management of modern global supply chains.

1 INTRODUCTION

In many academic papers, as well as in many statements of the business specialists on logistics, one can find an opinion that warehousing is nearly the main indicator measuring the inefficiency of supply chains [1, 2]. The assessment and optimization criteria usually include stock sizes as negative values, the *just-in-time* principle is ablolutisated, the presence of stocks in delivery channels is criticized and elimination of these stocks serves as a top objective of the supply chain structure's optimization [3, 4, 5]. Main methodological reason behind this perception is in the significant difference between the objects and subjects of the two disciplines, *logistics* and *transportation logistics*. The intention to get rid of any stocks could be compared with the long lasted desire to use only "direct" operations in sea ports, i.e. those not using transit warehouses [6]. In modern port-oriented logistics this principle is abandoned, the sizes of the warehouses and socks stored on them being regarded not only inevitable, but even serving as important instruments for system-wise optimization of transport and logistic mechanisms [7]. This paper offers the decisive rule to distinguish between the gnoseological domains of general and transportation logistics, investigates the factors caused the shift of this perception in maritime transport, and explains the necessity for similar changes in the field of design and management of global logistic supply chains, which is the best definition for the "*transportation logistics*" as the scientific discipline.

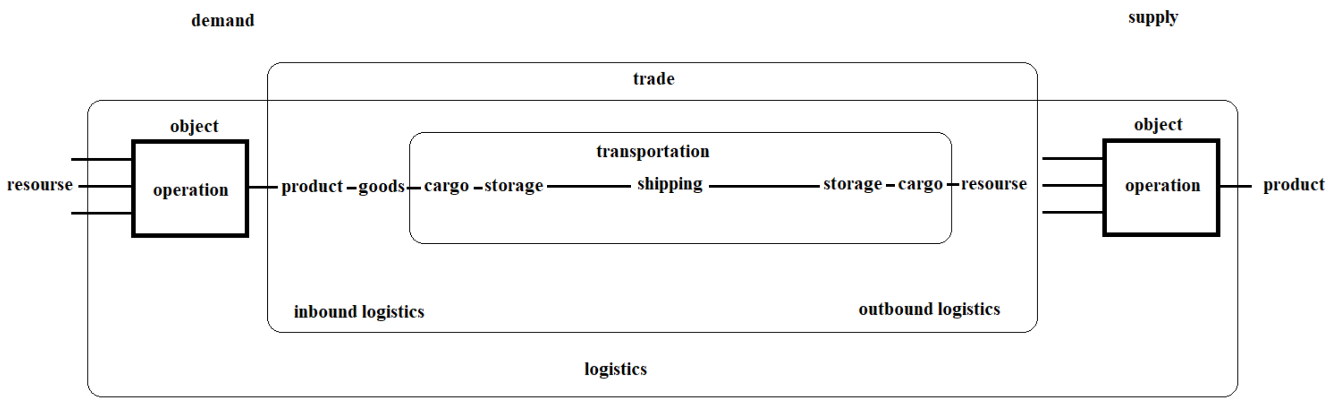

Figure 1. Relations between different entities and categories in a single logistic supply chain

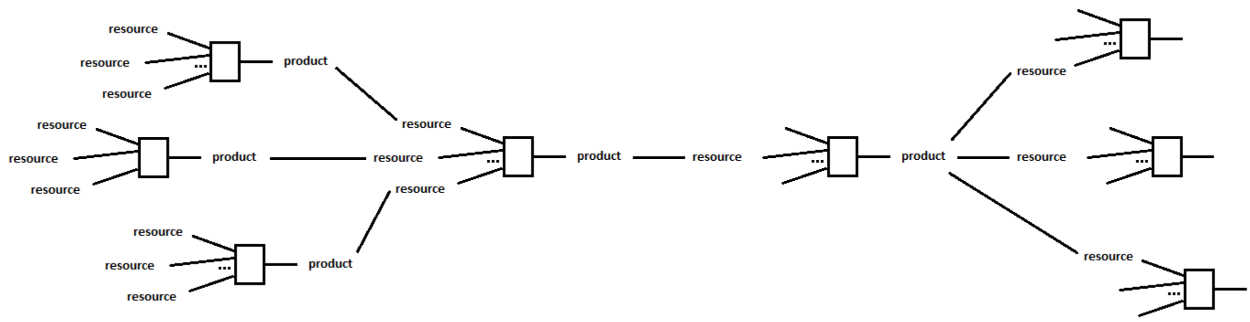

Figure 2. Logistic supply chain

2 METHODS AND MATERIALS

Traditionally, any system is defined as a set of elements and interconnections between them, aimed to carry out a certain activity (or "achieve a certain goal") [8]. The goal of any transportation system is to satisfy an existing demand for a product by the corresponded supply of it. Any of these two general categories are characterized by their own specific space localization, value and dynamics.

The demand could emerge in some point A, the supply to satisfy it – in a distanced point B. In order to annihilate this demand-supply pair the transportation of the bearer between these two points is needed. An abstract relation between above mentioned entities in a single supply chain is displayed by Fig. 1.

Logistic objects, transforming resources into products and exchanging them among each other, constitute complex and ramified space of links. Any sub-set of these links, selected by *ad hoc* criteria fitted to a certain research task, form abstract logistic concept of *supply chain* (Fig. 2).

If the subjects – the bearers of the demand (e.g. tourists or fishermen) are transported to the location of the supply to satisfy it, the passenger transportation link appears. If the demand is to be satisfied by a certain product that the manufacturer sells to the consumer (thus turning products into goods), then the goods transportation link emerges. The goods to be moved in the interests of the seller (manufacturer) to the buyer (consumer) by a third party (carrier) become cargo.

The relevant super-system, whose structure is oriented not for single act of one pair of demand-supply annihilation, but for ensuring the satisfaction of steady and massive set of permanently emerging pairs of the kind, located in different geographic regions, and responsible for sufficiently big total volume of cargo (i.e. goods and i.e. products), constitutes solitary and stand-alone cargo transportation system. This system consolidates the multidimensional array of demand-supply pairs, setting in motion the required material flows in the same way as the world trade system consolidates them in the aspect of the economic exchange covered by trade agreements and contracts. The correspondent material and all relevant flows (information, monetary, title, insurance etc.) should be not only sufficiently big, but quasi-stable and quasi-stationary, thus justifying the expenses for creation and maintenance of the cargo transportation system.

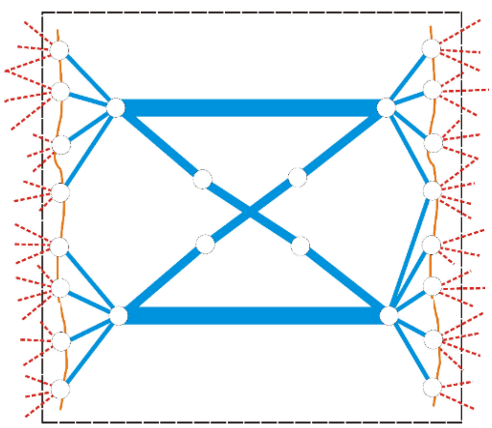

Figure 3. Transportation between two sets of demand-supply pairs as the object of transportation logistics

Fig. 3 illustrates a simplified concept of the transportation system that satisfies the demand for transportation generated by a set of single logistic supply-chains between two arbitrary geographical areas (sea facades in this case).

Under this problem statement, the transportation logistics involves only movement of cargo, thus excluding productive operations, i.e. any transformations of inbound resources into outbound products. Instead of that, the transportation logistics focuses on the operations of consolidation and distribution of cargo, optimized by criteria of different transport modes and their combinations. The new *transport-logistic chains* appeared as the result of this consideration, reflect another measurement of the space formed by the global material production, distribution and consumption. As Fig. 4 shows, the size and complexity of these chains do not cede the supply chains of traditional logistics (Fig. 2).

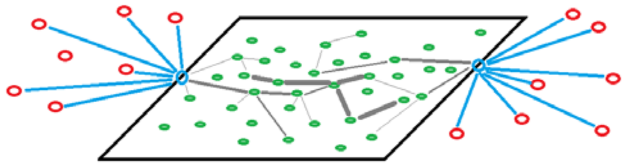

Figure 4 Transport-logistic supply chain

The definition of the content, the design of the structure of this big and autonomous system, the formulation of the lows of its operation, the study of its efficiency and stability is the core of the scientific discipline called the transportation logistics. The relevant and equal by the scale, complexity and coverage trade system (territorial, regional, international, global) serves as the "teleological environment" for the existence and development of the transportation logistics system. At the lowest "ground" level of the logistic supply chains regarding the flows of individual products, the transport function turns into a component of the inbound or outbound logistics, according the traditional definitions [9]. In many ways, this the function in general logistics assumes the knowledge of how to use the cargo transportation system of proper level. As a mean of supporting the international trade, the transportation logistics form its own scientific domain with own specific lows and methods.

The absence or disappearance of the above mentioned set of constantly emerging pairs of demand-supply causes the collapse of the transportation system, the lack of the possibility to deliver cargo lead to the principal inability to satisfy the demand.

Movement of product between points A and B located in different geographical regions is no a sole goal of the transportation system. As was discussed above, the demand and supply are characterized by localization, volumes and dynamics, with movement answering for only one requirements of logistics: the provision of products in due place [9]. On the other hand, demand and supply could be spread not only in space, but also in time: for example, the demand for heating coal appear in winter (peak demand) while by technological reasons its extraction should be even (stead supply). The harvest we take in in summer time (peak supply), while we consume collected grain all the year (steady demand). Thought annual volumes of demand and supply are equal, the temporal differences cause the need to store products (goods, cargos) in this or that location – at manufacture's premises, at consumer's premises, or – as will be discussed further – in the transportation system itself.

These two sample show that the presence of a warehouse and the existence of the product stock on it are an inevitable pre-condition for fulfillment of the second requirement of logistics: the provision of products in due time [9]. This necessity arises in any delivery of cargos (or goods, or even better – products) described by different degree of seasonality or market demands.

The third requirement of logistics, i.e. provision of products in due quantity, also needs the warehousing to be satisfied. This is explained by the need to accumulate the volumes of cargo from manufacturers to form shipping consignment which sizes meet the economic demands of carriers. The cargos from manufacturers arrive more or less evenly, and upon reaching a certain amount moved at one time from point A to point B as a unified shipping consignment. The collection (consolidation) of the cargos in point A and dispatching (distribution) to consumers in point B form equally important parts of the total cargo transportation system, as Fig. 5 illustrates.

a1													
	1								b2				
		1								1			
			1								1		b3
				1								2	
a2	1	1	1	A	3							2	
			1			3						2	
		1					3				B		
	1							3	3	3		1	
a3													b1

Figure 5. An example of simplified transportation system

This figure shows the products produced in locations a1, a2, a3 and delivered to point A. The collected consignment is moved from point A to point B, wherefrom is delivered to consumers in locations b1, b2, b3.

The representation of the transportation system over the fragment of plane allows to build a perception of spatial aspects of its operation. Simultaneously, the products in locations a1, a2, a3 could be produced in different time, which might require to store the products arrived earlier in order to wait for the formation of the required consignment. Same could happen at point B: some cargo could be delivered too early for consumers in different locations b1, b2, b3, which would lead to necessity to store their products for the synchronization with demand on them.

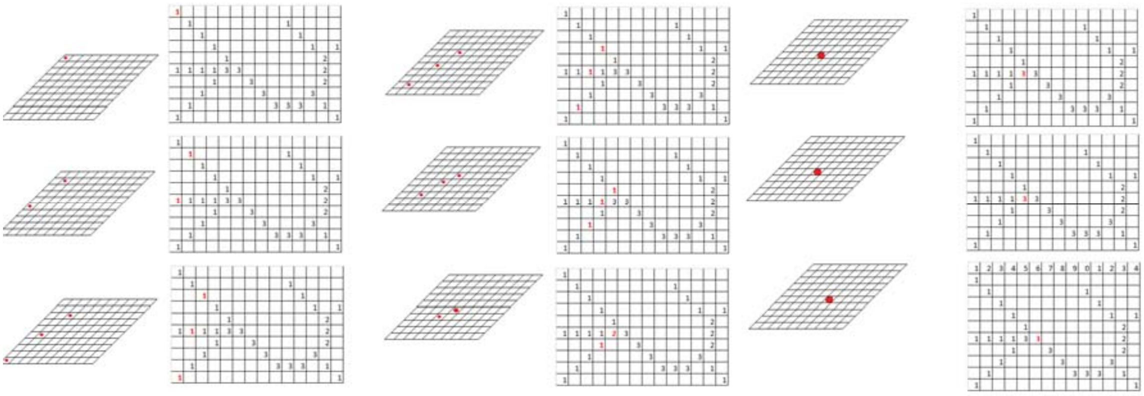

Figure 6. The consequent stages of simplified transportation system's operation

Moreover, there exists one important additional aspect: the cargo left an initial location does not arrive at target location instantly, it remains sometime in the process of moving. This amount of cargo (usually referred to as "stock on wheel") could be significantly big: for example, ten container ships "Panamax" class on their string to a port easily could carry as much as 20 000 boxes, while the port's container yard keeps only a half of this amount.

Fig. 6 arbitrary details not only movements of cargo between different locations shown by Fig. 5, but also the "schedule" of these moves in discrete time.

Every plane on this figure reflects the state of the system in an arbitral discrete time moment. In other words, the transportation in this perception is the movement of cargo in a three-dimensional space {*X*, *Y*, *t*}, where *X* and *Y* are common spatial coordinates, and *t* is the discrete time.

Fig. 7 illustrated the operation of this simplified transportation system in this arbitral space-time continuum.

Fifure 7. Operation of the simplified transportation system in {X,Y,t} space

Since usually in transportation management we do not regard the movement over the surface of the Earth in separate special coordinates {X, Y} and more interested in distance, as well as for the sake of visibility, we can examine the transportation system's operation in two-dimensional arbitrary space {*S*, *t*}, where S is the distance of the movement *S*=*S*(X,Y). A sample of this operation, or the systems' trajectory for a single ordinary transportation between two points is given by Fig. 8.

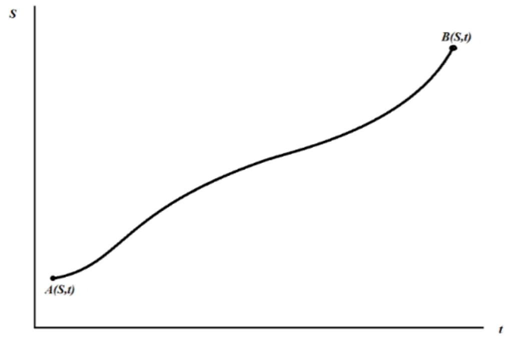

Figure 8. The trajectory of the transport system operation in time-space coordinates

This figure displays the operation of a simplified transportation system as the functional dependency of the distance from transportation time, i.e. *S=S(t)*. Obviously, the ratio (time derivative) is the transportation speed in this system.

On the other hand, the operation of this system could be equally represented as dependency of transportation time from covered distance, or *t=t(S)*, which Fig. 9 shows.

In this case the ratio (space derivative) is the delay connected with the transportation over the correspondent route, which is important separate characteristic of the transportation system's performance.

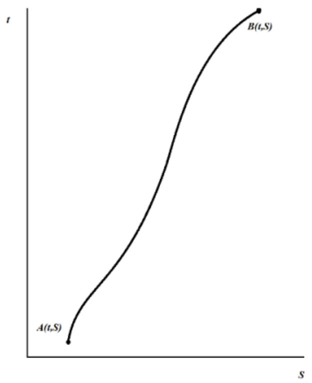

Figure 9. The trajectory of the transport system operation in space-time coordinates

For this delay two factors could be responsible simultaneously: the storage (or "transportation with zero velocity", as some logisticians say) and the transportation process between the initial point and destination itself, when the cargo is on its way. In the spatial representation these two factors differ in the way that in pure storage the correspondent trajectory is orthogonal to the special plane, or collinear to the time axle, as Fig. 10 shows.

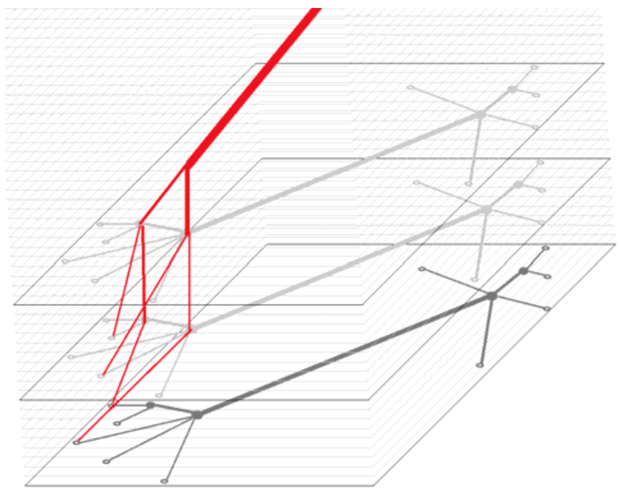

Figure 10 Movement and storage as components of the transportation

This figure shows that the traditional problem statement for the selection of the optimal transportation route is only a projection of the whole transportation schema in the space-time continuum (Fig 10) on the plane of the physical (geographic) plane (Fig 11).

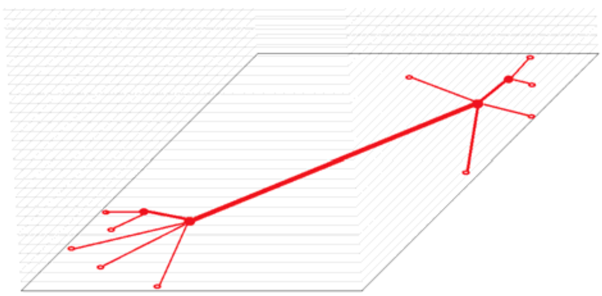

Figure 11. Projection of the transportation schema on the geographic plane

The accurate or approximate solutions of this problem, traditionally offered by the classical mathematics (in the section of transportation tasks), in this way is incorrect by its primary setting. In addition, the available methods and algorithms in practical cases are restricted to a small set of heuristics and crude simplifications.

Moreover, up to this moment we have been examined only on transport "transaction": consolidation of one cargo consignment for a single vehicle to meet the economic requirements of the transport mode, transportation of this consignment to an intermediate point, and distribution of the shipments by final destinations. Even for one such a route, or string, there emerges a correspondent task for the backhaul route. The next cycle, correspondent to a new round trip, will in its turn require to solve the problems of similar structure but with individual data sets. The common collection of different strings by an average company forms the problem space many times multiplying the algorithmic complexity of the task. The variety and great numbers of shipping lines operating on the market of ocean, sea, cabotage and river shipping, totally and absolutely deprive the problem of their total or partial optimization of any perspectives.

In the same time the carriers, totally unaware of this methodologic catastrophe, proceed with successful navigation, the cargo owners still buy their services, the investors still put their money in the business with intension to get profits.

Obviously, the business practice manages to solve this problem somehow, since it seeks not for the best, but for a tolerable solution. The question only remains whether this best (optimal) solution exists and how far away from it are these tolerable solutions. The answer for this question defines also whether we need to take efforts to develop more powerful mathematical tools that will provide sufficient competitive advantages to justify the cost and labor for their development and introduction.

3 DISCUSSION

We came to a conclusion that the transportation process, implicitly or explicitly, consists of two components: movement in space and movement in time. The movement in space, due to the finite transportation speed, inevitably generates the movement in time (by the stock on wheel). The movement in time could not be connected with any movement in space, thus performing the function of pure storage. This function is required both be technological reasons (accumulation of the transport consignment) and commercial ones (coordination of the demand-supply seasonality, fluctuation of the market conjuncture, billable warehousing services etc.).

All these factors should be taken into account in any optimization problem statements concerning different aspects of design and management of transportation systems. Really, even the classical problems of linear programming should be re-formulated from traditional "static" format to the new “dynamic” one with constantly changing input data. With big share of probability this excludes from the list of possible candidates for the new methodologic toolkit nearly all traditional analytical calculation techniques as inefficient and inadequate.

Actually, in any of these dynamic variants of the problem statement for the mathematic programming problem, in any individual moment we have to solve a new task with new data and even a new statement. If recall that every separate task of the kind is NP-complete, then the computational complexity of the problem solution becomes too high.

A separate direction of studies could be modification of the classical problem statement by including the time as equal variable to spatial ones. In the same time, this approach hardly ever would avoid the well-known problem of “combinatorial explosion”.

Consequently, all these circumstances leave us with no methodological instruments we used to use in order to solve any transport optimization problems at previous stage of development of supply chains. In the same time, new demands for operational characteristics of these global supply chains put more and more hard requirements for this optimization.

Obviously, we should seek the solution of this contradiction in new fundamental scientific disciplines, like cybernetics and discrete mathematics, and in the impressive progress of computer hard- and software.

4 CONCLUSIONS

1 The transportation logistics, regarded as an instrument for design and management of the global intermodal supply network, is an autonomous discipline which should not be mixed with transportation functions of inbound and outbound general logistics.
2 The principle of excluding warehouses from supply chains refers to several important but individual cases of specific objectives and system's configurations.
3 Any cargo transportation includes two component: movement in space (shipping) and movement in time (storage).
4 The storage could take shape of inevitable ”stock on wheels” or separate stock in warehouses.
5 Different configurations of supply chains could alter the relative importance of these components, but in majority of cases do not permit to neglect any of them.
6 The design of complex supply chains in general case needs to take into account both spatial and time parameters, which demands for a new problem statement of the relevant mathematical tasks and deprives the traditional methodological apparatus of its adequacy.
7 The design of modern global supply chains needs the development of a new paradigmal approach, with the simulation modelling seemed to be the most promising tool of it.

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