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OPTIMIZATION OF THE TRANSPORT CHAIN FOR GOODS DISTIBUTION

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Summary: *First part of this paper mostly consists of information on general properties and the significance of the goods distribution according to the logistics concept. Transport chain is an important part of such concept and it can be formed in several different ways depending on the involving factors. Second part of the paper focuses on the conditions and possible choices for the optimum transport chain variation in the cases of multi-attribute decision-making.*
Key words: *Distribution channel, transport chain, multi-attribute decision-making.*

1. INTRODUCTION

During the last several years manufacturers have been faced with the intensive alterations of the sales market caused by the varying customer demands. These demands, while focused at the functional properties of the products, are now decisively targeting the properties and the quality of goods delivery. By adjusting to these changes, taking them in consideration and satisfying the rules of demand, manufacturers have been looking for different approaches to the sales markets and the consumers themselves. One such approach is the production based on common demands, transformed in a recognizable logistic concept. Well-formed channels of physical distribution and their destinations are the key elements in the realization of business arrangements. Main part of the distribution channel is a transport chain which consist of numerous and diverse technological elements. They should be based on the important logistic strategy and a concept created on the dividing interests of all involved parties, synergetic action and a global optimization in the conditions of multi-criterion analysis.

2. TRANSPORT CHAIN AS A BASE OF THE DISTRIBUTION CHANNEL

Transport of the goods from the manufacturer to the customer (consumer) is achieved via distribution channels. Their structure can be of different complexity, which is affected by several factors: market characteristics, product types and their characteristics, phases of the product's life cycle, available infrastructure and similar. Complexity of the distribution channels is commonly expressed in two dimensions:

- Vertical, which represents series of connections and dots, number of levels in fact, in the channel connecting the manufacturer with the customers (consumers), and
- Horizontal, which determines the number and branching off of the intermediary dots on a distribution chain level.

Having this is mind, different distribution channels of various structures and complexity can be identified: from the direct ones, to the different types of indirect channels and their combinations. Distribution channels are characterized by two basic components:

- Marketing, which makes several transactional functions possible and increases the value in this segment, and
- Logistic, which reflects on the physical distribution and increase of the product's value based on space and time.

Logistic component's key factor in a distribution channel is transportation. Product's change of location in this channel, between two points of transaction, can be achieved with use of different forms of transport and their combinations. Transport chains of different complexity and influence upon the final effects and the properties of the logistic service levels can also be formed. And so, technological part of the goods transportation between the dots of the distribution channel is the transport chain. It can be defined as a group of timed and associated actions of transporting, reloading and storing.

Forming a transport chain means forming all parts and processes, connecting, synchronizing and integrating them all together (figure 1). Various possibilities associated with the types of transport, transporters, transporting routes, locations for the change of vehicle type, reloading and storing conditions, possible cargo types, delivery dynamics and so on. This is how several potential variations with different properties and effectiveness are derived.

3. TRANSPORT CHAIN OPTIMIZATION

From numerous transport chain varieties which can be formed, it is necessary to decide on the one which will be realized. This is a typical handling process whose results are directly depending on the methods of its realization and available instruments.

Optimal variation of a transport chain can be created in several steps [1]:

- defining logistic and transport demands,
- gathering and analysis of relevant information,
- forming of mathematical model,
- finding the solution for the model at hand,
- validation of derived results,
- deciding on the best solution.

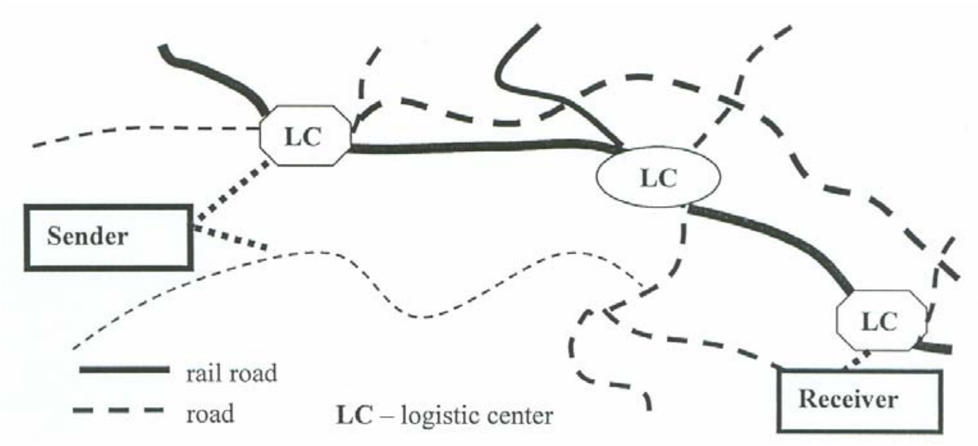

Figure 1. Illustration of a possible transport chain on the traffic grid

This type of task is usually solved by minimizing one of the most commonly used alterable criterions, more precisely limitations: of covered distance, operation costs and time required for the accomplishment. In other words, the problem is treated in the manner of a single-criterion issue. Depending on the properties, optimal transport chain can be found if all properties are taken in consideration, namely it has to be treated as a multi-criterion issue.

Transport chain falls into the group of „badly structured problems". Due to this, solution can be found by using multi-attribute decision-making, namely using multi-attributive programing techniques, whose general formula is [2]:

$$\max \ [f_1(x), f_2(x), ..., f_n(x)] \tag{1}$$

Involving limitations

$$\boldsymbol{x \in A = (a_a, a_2, ..., a_m)},$$

where:

$\boldsymbol{f_j}$ – criterions (attributes), $j = 1,2, ..., n; n\geq 2$

$\boldsymbol{A}$ – group of alternatives

$\boldsymbol{a_i}$ – alternative considerations (varieties), $i = 1, 2, ..., m$

Value of every alternative $[f_{ij} = f_j(a_i)]$ can be of quantitative and qualitative nature. Criterions in this case do not have to bear the same significance on the choice for the optimal solution, and this is regulated by defining the weight coefficient – the significance factor [3].

By considering the mentioned facts, suggested model of the optimal transport chain type has a following setup:

Transport chain variation	min f_1	min f_2	min f_3	max f_4
a_1 **a_2** . . . **a_m**	f_{11} f_{21} . . . f_{m1}	f_{12} f_{22} . . . f_{m2}	f_{13} f_{23} . . . f_{m3}	f_{14} f_{24} . . . f_{m4}
w_j	w_1	w_2	w_3	w_4

where:

f_1 – transport costs (train transport costs),

f_2 – additional costs (reloading, storing…),

f_3 – time required for the delivery,

f_4 – quality of the delivery service (presented descriptively or in according size),

a_i – transport chain variation,

w_j – certain criterions importance rating (weight coefficient).

Every type of transport chain (a_i) going from the sender to the receiver has specific properties (attributes – f_j). According to the measurability rate, they can be qualitative and quantitate [2]. Number of available attributes depends on the factors affecting the process of selecting the optimal variation. Number of attributes increases symmetrically with the number of factors taken in consideration, but the potential identification and distinction between their separate effects on specific alternatives reduces.

Cost of train transportation (f_1) depends on the present transport fees of certain transportation types and their properties. Internal costs are relevant if own-account transport resources are used. Additional costs (f_2) can be caused by various requirements for reloading (in cases of combined transport, use of logistic centers), storing (on locations of transport vehicle change, transport chain „breaking off" points due to the use of logistic centers), creation of transporting (logistics) units according to the special demands associated with the type of transportation and similar. Time of the transportation (f_3) is a relevant property which can significantly impact and increase the amount of goods in the distribution chain (goods in transport), delivery dynamics and similar. Quality (f_4) is a property of a transportation which can manifest itself through different properties with appropriate quantitative indicators of various optimization „methods "(example: reliability, flexibility, goods damage rating...). Thus, this factor can be diminished and instead of f_4 several criterions in the process of decision-making can be introduced. In the cases when quantitative indicators are lacking (for example: due to impossibility of their identification- measurement) qualitative indicators can be applied (they will be transfigured in quantitative with the use of certain techniques).

Significance factors (w_j) define the involving criterions importance, in varying degrees, used in the transport chain rendering as a part of the distribution channel. If we bear in mind the level of entropy, this means that the lower weight coefficient is a characteristic of a more undefined attributes (with more consistent values found in certain variations). Several methods can be used for finding the weight coefficient value (such as rating method, ranking method, pair-comparing method, and so on).

Additive weight method is mostly used for ranking various transport chain choices. Every identifier – attribute (with converted and standardized values marked with f_{ij}') receives an appropriate weight coefficient which becomes a coefficient with a variable (transport chain's attribute).This provides the function of every transport chain system.

Ranking (interposition) of the present states in the group of defined variations is determined by the following expression:

$$a = \sum_{j=1}^{n} f_{ij}' \cdot w_j \qquad i = 1,m \tag{2}$$

$$0 < w_j < 1; \quad \sum_{j=1}^{n} w_j = 1 \tag{3}$$

Finding the solution for this problem can be achieved with the use of several methods which provide fragmentary or definite ranking of the alternatives. Correct model provides the best transport chain variation according to the presented demands. We have to state that other criterions can be introduced as well, or the used criterions diminished in order to get new attributes.

4. CONSLUSION

Constructing a transport chain for the product distribution is a complex process which demands that all technological requirements are taken in consideration and that all technological elements needed for the realization, such as numerous participants and their capabilities and requirements, various administrative and other limitations, and others, are selected. Problem becomes even more complex when distant (for example: oversea) markets are involved, because number and form of influencing factors significantly increases. Bearing this complexity in mind, paper provides a model for an optimum variation of a transport chain in the conditions of multi-attributive decision-making.

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