CHOICE OF SUPPLY CHAIN OPTIONS IN MULTIMODAL TRAFFIC

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ABSTRACT

To solve market competitive problems Russian enterprises, the authors believe, should implement an integrated approach to the development of supply chains for transportation over long distances (such a situation occurs more often while introducing a new product to the market when it is delivered directly from the manufacturer factory). In this case, the transport component is of particular importance, as it may significantly exceed the share of other logistics costs. Demonstrated approach to the design of delivery of goods takes into account the alternative choice. It is proposed to assess not only the most optimal (in terms of cost and integrated indicators) options, but to take into account those in where a certain benefit or important social aspect with more distant consequences for the production itself is prevailing. Examples of calculations, models and methods of designing logistics systems are presented. It is expected that the developed methodology can be used for individual subsystems – for example, purchasing, transportation, warehousing, inventory management.

Keywords: transport, economy, logistics, supply chain, multimodal transportation, design, transportation, logistics costs.

Background. *Exploring options for selecting supply chains, one should bear in mind the scale of changes that have occurred over the past few years in global trade and logistics. There was a complete reorientation of values – today the logistics task is not simply reduced to the concept 7R, but should satisfy customer demand at a given level. In such a situation it is necessary to upgrade and constantly improve logistics and marketing system, to consider previously disparate operations within a single process format. External or indirect factors can have a significant impact on the logistics system (e. g., political situation, environmental safety, corporate social responsibility). It is important to understand that under the conditions of the Russian economy and the geopolitics a transport component plays often a decisive role. It accounts for 20 to 70% of all costs in the supply chain.*

Analysis of the literature showed that the design of supply chain and logistics efficiency assessment are neglected. The researchers of both domestic and foreign logistics consider supply chain design issues locally, and often without offering any analytic or methodological tools. On the one hand, this situation can be explained by a relatively small period of time of development of logistics as of an independent scientific field. On the other hand, needs of practice promote accelerated development of the supply chain issues.

In this respect, although debatable, the opinion of experts [1, back translation into English from Russian] is indicative that «the supply chains have not been specifically designed but have been formed over time, in a kind of organic way». However D. Bowersox and D. Closs [2] consider the supply chain design process from the position of reengineering of logistics systems, indicating the priority of this procedure.

In the works of Russian researchers and specialists it is emphasized above all, that designing of supply chains along with their further evaluation in a market economy requires an understanding of some basic principles. Firstly, when transporting FMCG (consumer goods) for short distances and in small batches logistics operator can successfully use the experience of foreign colleagues, using vehicles with good performance and long daily run and the ability to respond rapidly to market demands. Secondly, the transportation of cargo to remote regions of Siberia and the Far East by maneuverable and fast motor transport is expensive, particularly due to the lack of proper service en route. For such transportation preferred priority, of course, is the use of rail transport, less maneuverable, but more resistant to environmental changes.

Objective. *The objective of the authors is to consider the issues related to choice of different delivery options, which are applied in multimodal traffic.*

Methods. *The authors use general scientific methods, comparative analysis, evaluation approach.*

Results. *The growing interest in improving the efficiency of the entire supply chain updates the approach to choice of economically viable options. The concept of multimodal transportation is most suitable for that purpose. Multimodal transportation is transportation of cargo by several modes of transport, when one of the carriers organizes under his full responsibility all the delivery from one point of origin passing by one or more transshipment points to the destination while issuing a single consignment note and at a single rate of freight.*

Adequate assessment and selection of different variants of the supply chain, based on domestic conditions and specificity of the transport component, assumes a comprehensive approach that takes into account all interdependencies with the existing logistics system, configuration of regional links and infrastructure of roads.

The transport component of logistics in Russia takes on special significance in view of unique transport distance, features of the transport infrastructure, as well as difficult climatic conditions. Domestic transport companies, solving such a complex set of tasks, fully utilize the experience of foreign partners. For example, the principles of formation of multi-modal logistics systems, advanced systems of navigation and cargo tracking, control over temperatures in refrigerated vehicles, basic provisions of JIT (just-in-time) concept, QR (quickresponse), etc.

Pic. 1 shows an algorithm of multiple calculations in designing supply chains, including the accounting of marketing requirements. It organically combines the basic principles of logistics, decomposition and elements of strategic management.

The algorithm includes the phased implementation of the following objectives: first, source data are defined, demand and its variability are taken into account; then transportation process is designated, for example on the basis of the network schedule; further reserves are calculated (EOQ, safety stock),

Table 1

Models and methods used in designing of logistics systems

Source	Dependence	Comments
Anikin, B.A., Tyapukhin, A.P. [3]	$C_{\Sigma}=C_A+pt_A$	C_A – price per unit of goods of an enterprise p – transport tariff t_A – distance from enterprise A to a consumer
Bowersox D.J., Closs D.J. [2]	$\sum \frac{Pv^- + Tv^-}{Nx^-} + Wx^- + \lambda x^- \ll \sum Px^- + Tx^-$	Pv^- – costs of cargo handling of consolidated cargo shipment Wx^- – costs of warehousing of medium-sized consignment λx^- – costs of local delivery of medium-sized consignment Nx^- – number of medium-sized shipments in the consolidated shipment Px^- – costs of cargo handling of medium-sized shipment Tx^- – transit costs for direct delivery of medium-sized shipment
Gadzhinsky, A.M.	$R_n = \sum^n Ci + K / T$	R_n – reduced costs Ci – annual operating and other costs K – total investments T – payback period
Ryzhikov, Yu.I.	$T^* = \sqrt{2q_v / (S\lambda n)}$ $L^* = \sqrt{2q_v \cdot S\lambda n}$	T* – optimal frequency of deliveries L* – minimum costs at T* q_{Σ} – amount of transit charges for this organization of transportation S – service district area λn – density of value demand

which are analyzed by ABC method, etc. The next step is to determine the optimal size of lots for delivery along the best routes to customers, and then once again accounting of marketing requirements is performed. At the last stage in case of a negative result it is necessary to pay attention to the number of customers and the demand for each of them; for these purposes methods of analysis and correction of administrative decisions based on KPI are applied.

Transportation as a function of logistics and transport costs play a crucial role in the design of supply chains. Traditionally, the term «transport» means a sector of material production, transporting passengers and cargo. However, the current economic development has brought transport close to the logistics function, allowing thus to consider the transport component in terms of system approach in integrated supply chains.

Table 1 shows the main dependences used in the design of logistics systems, the analysis of which will form the necessary methodological basis for solving the problem of delivery of goods.

From the analysis of Table 1 it follows that when transporting over long distances (just such a situation occurs more often while introducing a new product to the market when it is delivered directly from the factory) the transport component is of particular importance as it may significantly exceed the other components of total logistics costs TLC.

The equation for finding the optimal size of a single delivered lot:

$$S_{\text{opt}} = \sqrt{\frac{2A(C_0 + C_t)}{C_p f}} = \sqrt{\frac{2AC_0}{C_p f}} \cdot \sqrt{1 + \frac{C_t}{Co}}, \qquad (1)$$

where S is value of a delivery, units;

A – need for the product over a period, units;

C_p – unit price, conventional units, c. u.;

f – share of price C_p, attributable to the costs of storage, %;

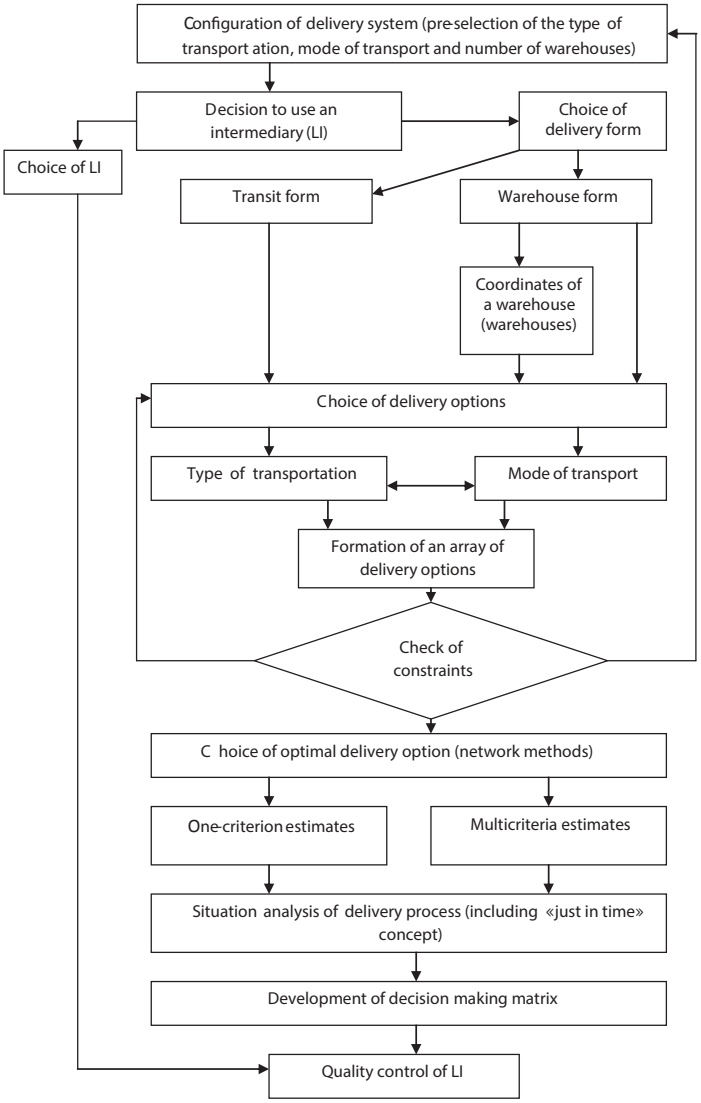
C_o – costs of execution of one shipment;

C_t – costs of transporting a lot.

Obviously, the value of C_t will vary considerably with increasing distance of unimodal or multimodal transportation, warehouse location and the need to cross the border, and presence of many other factors. Subject $C_t >> C_o$ the calculated value S_{opt} will reach and then exceed freight load capacity F or tonnage W of a vehicle. In this case, mass or volume of the lot will be determined by the value F (or W). Thus, in multimodal transportation of large quantities, it makes sense to focus on the costs associated with C_t, and for small volumes of supplies over short distances it is advisable to resort to EOQ model.

Of course, the logistics strategy aimed at cost savings, is committed to a fully loaded vehicle. Consolidation of shipments (which is typical for traffic with a large value of L, km) is optimal when dealing with the expected demand. But for logistics systems operating in response to demand, irregular shipments are characteristic, which increases C_t. At this point it is recommended to use consolidation of shipments according to market, delivery schedule or groups of shippers.

In a situation where transportation costs are much greater than other logistics costs, it is advisable to pay attention to the railways, which occupy a leading place in the transport system of the Russian Federation. It does not depend on the time of day, weather conditions, has high carrying capacity (80–90 million tons of cargo on a double-track line per year), universal rolling stock is suitable for all types of cargo. The disadvantages are not always reliable safety of the cargo, as well as the lack of established systems of control and monitoring of cargo in transit.



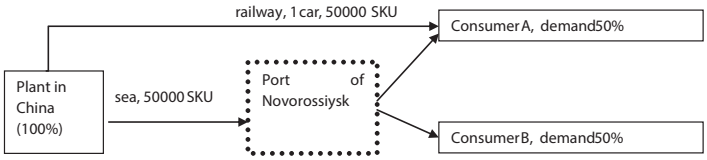
Pic. 1. The algorithm of multiple calculations of designing supply chains.

Table 2

Calculation results

Delivery option	C, c. u.	T, day	C*	l, km	V, km/h	$t_{acc}+t_{add}$, h	p, c. u.
Rail transport China – consumer A	2976000	7	1000401	5200	60	72	380
Rail transport China – consumer B	3395000	10	1000270	9580	60	72	250
Maritime transport China – consumer A	3840000	16	1000226	14200	45	72	200
Maritime transport China – consumer B	4125000	15	1000281	12500	45	72	250

Given the increasing role of international multimodal transportation, as well as relevance of market challenges, we set the following parameters for validation of the proposed method: enterprise N launches new product in «consumer products» category (FMCG) to the Russian market, the manufacturer plant is located in the port city of China; two consumers. For convenience of calculations, we introduce the concept of SKU (Stock Keeping Unit) as a unit of accounting of reserves, equal to the number of goods placed on 1 pallet, 1 SKU price is 20 c. u., the total demand is 100000 SKU. The consumer B is located in the central part of Russia, the consumer A – in Siberia. Goods in containers first



Pic. 2. Scheme of transportation from China.

go by sea to the port of Novorossiysk.

*In modern practices, the choice of delivery option is based on parameters of time (T), cost value (C), or the integrated indicator (C *),*

$C^* = (C_g + C_t)(1+\Delta)^n$, (2)

where C is integral estimation of cargo delivery with account of cost and time;*

C_g *– purchase price of goods (in a simulated situation* $C_g = CSKU^*k$,

where κ is need of consumers for SKU);

C_t *– cost of transportation;*

$(1+\Delta)^n$ *– buildup factor for the interest rate* Δ *(let's take its mean value over medium-term currency loans* $\Delta = 15$*) for n periods, n = T/365 days.*

Let's calculate the indicator C, based on the formula proposed in [3]:

$C_\Sigma = C_A + pt_A$, (3)

where C_A *– price of a unit of goods of an enterprise;*

p – transport tariff;

t_A *– distance from an enterprise A to a consumer.*

For calculation of T we use the formula 4 [3] for a rail transport:

$T_r = t_{acc} + l/V_{rn}$, (4)

where t_{acc} *– accumulation period;*

l – distances from a manufacturer to a consumer, $l = t_A$;

V_{rn} *– norm of run per day according to the rules approved by the Ministry of Railways of Russia dated June 18,2003 № 27;*

$t\!/_{add}$ *– additional time for specific operations inherent in rail transport.*

Calculation of delivery time for maritime transport:

$T_m = l/V_m$.

Table 2 shows the final options of delivery of a new product in the Russian market by two types of transport, taking into account production volumes, and priority criteria (C, T, C).*

Thus, depending on the set time parameter, value or present value of C for both consumers a choice is made in favor of rail transport.*

Conclusions. *The paper presents the design methodology of delivery of goods taking into account the alternative choice. It is proposed to assess not only the best (in terms of cost and integrated indicators) options, but to use an integrated approach to solving the problems of determining supply chains to be used. Taking into account the geographical characteristics of the Russian Federation, it is necessary to perceive the real essence of the alternatives in each case, and not to be guided by generally accepted postulates (for example, relationship between the efficiency of road transport and railways).*

It is worth emphasizing that in this case only a part of the design process is considered in detail, the issue of transportation, and further studies should relate to the situation with reserves, the choice of management strategy, deficit, safety stock, etc. It is advisable to think about and to support with software the use of IT for multivariate calculations, analysis of results and development of databases within this new field of logistics.

REFERENCES

1. Stock, J. R., Lambert, D. M. Strategic Logistics Management [*Strategicheskoe upravlenie logistikoj. Transl. from English*]. Moscow, Infra-M, 2005, 797 p.

2. Bowersox, D. J., Closs, D.J. Logistical Management: The Integrated Supply Chain Process. [*Logistika: integrirovannaya cep' postavok. Transl. from English*]. Moscow, Olimp-Biznes publ., 2001, 640 p.

3. Anikin, B. A., Tyapukhin, A. P. Commercial Logistics: Textbook [*Kommercheskaja logistika: Uchebnik*]. Moscow, TK Welby; Prospect, 2005, 432 p.

4. Bobkova, V. M., Lukinsky, V. S., Lukinsky, V. V., Troy anov, A. E. Strategy of transport enterprises reengineering: educational guide [*Strategija reinzhiniringa transportnyh predprijatij: Ucheb. posobie*]. St. Petersburg, GIEU, 2005, 115 p.

5. Corporate logistics. Questions and answers [*Korporativnaja logistika. V voprosah i otvetah*]. Ed. by V. I. Sergeev. Moscow, INFRA-M, 2013, 634 p.

6. Logistics: educational guide [*Logistika:Ucheb. posobie*]. Ed. by B. A. Anikin. Moscow, Infra-M, 2002, 200 p.

7. Models and methods of logistics theory: educational guide [*Modeli i metody teorii logistiki: Ucheb. posobie*]. 2nd ed. Ed. by V.S. Lukinsky. St.Petersburg, Piter publ., 2008, 448 p.

8. Christopher Martin: Logistics and Supply Chain Management, Creating Value-Adding Networks, 3rd edition, FT Prentice Hall, 2005.

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