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MODELING LOGISTICS NETWORKS TRADING COMPANY

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Соколовська З.М., Хрипко Б.Б. Моделювання логістичних мереж торгівельної компанії.

Стаття присвячена проблемам прикладного застосування методів оптимізації в економічних дослідженнях. Пропонується розв'язання задач, притаманних процесам функціонування логістичних мереж торгівельних компаній. Розглянуто використання моделей комівояжера та транспортної мережі для оптимізації логістичних ланцюгів типової торгово-посередницької компанії. Аналізуються фрагменти результатів проведених розрахунків на моделях; доводиться економічна ефективність їх впровадження.

Ключові слова: торгівельна компанія, логістична мережа, методи оптимізації, модель комівояжера, транспортна модель

Соколовская З.Н., Хрипко Б.Б. Моделирование логистических сетей торговой компании.

Статья посвящена проблемам прикладного использования методов оптимизации в экономических исследованиях. Предлагается решение задач, присущих процессам функционирования логистических сетей торговых компаний. Рассмотрено использование моделей коммивояжера и транспортной сети для оптимизации логистических цепей торгово-посреднической компании. Анализируются фрагменты результатов проведенных расчетов на моделях; обосновывается экономическая эффективность их внедрения.

Ключевые слова: торговая компания, логистическая сеть, методы оптимизации, модель коммивояжера, транспортная модель

Sokolovskaya Z., Khripko B. Modeling of logistics networks trading company.

The article is devoted to the problems of applied use of optimization methods in economic research. It is proposed to address the challenges inherent in the processes of functioning of logistics networks of trading companies. Explains how to use the models salesman and transport network for optimization of logistics chains trade-brokering company. Fragments are analyzed the results of calculations on models; justifying the economic efficiency of their implementation.

Keywords: trading company, logistics network optimization techniques, model salesman, transport model

Logistics trade company is a single integrated system the components of which are the logistics chain procurement and sales. The organization of an effective system reduces expenses of goods turnover in network "purchases-sales" due to minimization of inventory, movement of goods between the parties, elimination of unprofitable operations and contingencies costs. Among the logistical challenges that constantly decide the trading company, one of the main is the development and optimization of the system of movement of goods; the use of storage facilities; the interaction of all departments and branches, etc.

From the introduction of effective logistics technologies depend the success and competitive price-fashion trading company, which is especially important in conditions of growing competition in the background of the deepening crisis phenomena in the economy. At the present stage of economic development and business logistics is one of the most important factors of competitive struggle.

Analysis of recent researches and publications

The organization of logistic systems of enterprises, in particular trade, devoted a considerable number of works of domestic and foreign experts [1-6] etc. However, the continuous development of logistics systems puts the all-new unsolved problems whose solution requires the involvement of the relevant specific objectives of the mathematical apparatus.

As one of powerful tools for creating mathematical models of logistics systems offers optimization methods.

Optimization methods have been successfully employed in economic research to different spremo-deposits [7-9]. In particular, the methods of integer linear optimization fall into one of the most developed groups of optimization methods [8-10]. Based on them are built several standard models, which include the traveling salesman model and the model of the transport network. Today, in addition to the standard mathematical performances of the above models and there are a limited number of their modifications [10-11].

Unsolved aspects of the problem

Despite a well developed theoretical base, the application of the above methods on real objects of study are still limited in crisis conditions of the domestic economy. In addition, in actual implementation, the specificity of the studied processes makes adjustments to a standard formulation of optimization models, which generate new application modification.

The aim of the article is the construction of models of supply chain trading company using the models of a salesman and the transport network.

The main part

The object of the research was selected the company "EVERLONG", which deals with the import and distribution of foreign wines in Ukraine and provides services for the design of wine lists cultural and recreational facilities, staff training and wine etiquette tasting the basics of skill, the performance of highly skilled sommelier to conduct master classes and tastings; performs other advisory services.

The company has an extensive logistic network that consists of many sales channels. Among the distribu-tion channels of the company are such major players in the domestic retail market, ”Silpo”, ”Tavria V”, “Metro cash & carry”, “Auchan”, etc.

Sales system of the company consists of several segments:

— system distribution to wholesale and retail networks (component is its own network of wholesale and retail liquor stores – in particular, the network of liquor stores "Vine Spot");
— the system of distribution of objects of cultural and entertainment destinations;
— distribution system among small retail counterparties (small non-chain stores, retail outlets at gas stations, etc.).

That is, the logistic system of the company is focused on moving products from abroad and ensuring of the needs of branches in different cities of Ukraine (external supply chain). Internal supply chain consists of the movement of goods from warehouses to the actual counterparties.

During the company's logistics system is outdated and requires significant improvements. Nowadays it is especially relevant in the context of the socio-economic situation in the country. Changes in exchange rates resulted in a correspondingly significant increase in the prices of the products. The pricing policy significantly also influenced by the costs of the current system of distribution, the efficiency of which affects the ultimate performance of a trading company.

Analysis of the system of movement of goods to the company branches on the territory of Ukraine proved the following.

Products crossing the border is registered and shall be registered in the nearest branch, where it checks the integrity and compliance requirements. After that, the products are sent to Central repositories in Kiev, where subject to further storage until the distribution between contractors and movement to final points of sale.

1) The study of the routes of movement of goods (Fig. 1) bring their irrationality, inefficient increase in mileage runs. Besides after receipt of the machine with the goods to the stores branch, it should return to its original location in Kiev. That is, the distance is increased by doubling the path of movement of the cargo.

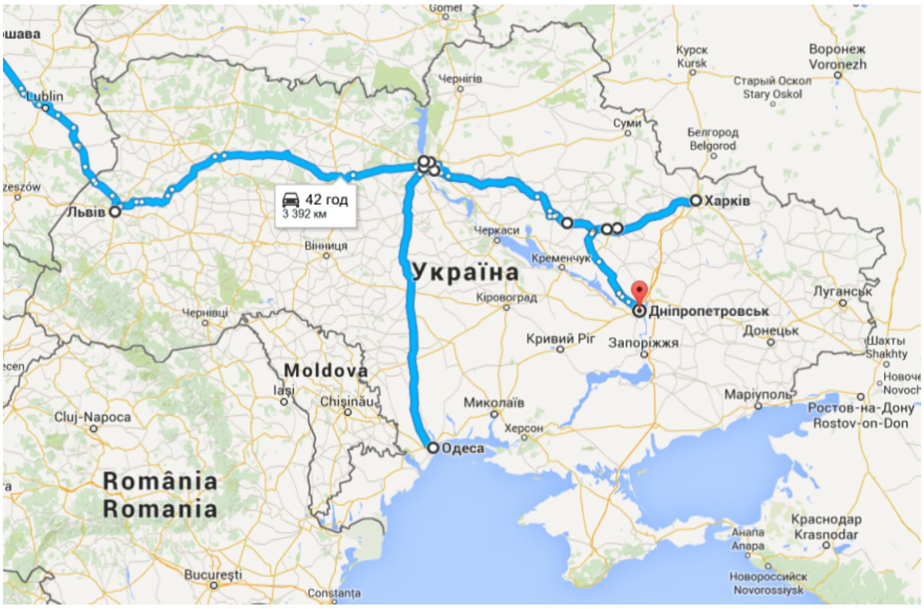

Fig.1. The route of distribution of imported goods in the company "EVERLONG"

Import and distribution of cargo takes about 4482,5 km. At known distances ("Lviv-Kyiv" – 540,9 km "Kiev-Odessa" – 475.3 km ; "Kyiv-Kharkiv" – 478,2 km; "Kiev-Dnepropetrovsk" – 476,4 km) and the current logistics chain ("Lviv-Kyiv"; "Kiev-Lviv; Kyiv-Odessa, Kyiv-Kharkiv, Kyiv-Dnipropetrovsk": 540,9 + 540,9·2 + 475,3·2 + 478,2·2 + 476,4·2 = 4482,5 km). To optimize external logistics chain, namely transport routes to minimize the runs (and thus transport costs) model was used to traveling salesman.

General formulation of the traveling salesman problem is as follows [10]. Let there be n cities to supply products. The cities are numbered with integers from 1 to n. The salesman, who travels from city 1, should visit each city only once and return to source paragraph.

2) Specified distances between cities

$$c_{ij}\ ;i,j=\overline{1,n}\ ,\ i\neq j.$$

Goal of solving the problem is to find the shortest route.

For the solution introduces the following variables:

$$x_{ij}=\begin{cases}1, & \text{if the route involved moving from i to j}\\ 0, & \text{if this is not the case (i, } j=\overline{1,n}\ ;\ i\neq j)\end{cases}$$

Then the mathematical formulation of the problem has the following form:

$$F=\sum_{i=1}^{n}\sum_{j=1}^{n}c_{ij}\,x_{ij}\ \to \min$$

Integer non-negative variables u_i , $i=\overline{1,n}$ introduced specifically for the entry of additional restrictions (their number is equal (n-1)(n-2)). This eliminates the possibility of a rupture of the route (i.e. the possibility of having closed half route).

$$\begin{cases}\sum_{j=1}^{n}x_{ij}=1;\ j=\overline{1,n}\ -\ \text{once the condition of entry to the city}\\ \sum_{i=1}^{n}x_{ij}=1;\ i=\overline{1,n}-\text{once the condition of departure from the city}\\ u_i-u_j+nx_{ij}\leq n-1;\ i,j=\overline{2,n};\ i\neq j\\ x_{ij}\in(0,1),\ \ u_i\geq 0,\ \text{the aim}\end{cases}$$

For solving the optimization problem used in the module "Searching for solutions" system Excel.

Input distance matrix (km) is as follows – table. 1. Input routing matrix (defined random routes) is as follows – table 2.

In the result of solving the problem obtained the following matrix of optimal routes – table 3.

It corresponds to the matrix spans (km), indicating a significant reduction in mileage (2513,9 km) compared to the existing – table 4.

Table 1. The distance between cities of location of branches of the company "EVERLONG"

City – points of departure/destination	Lviv (1)	Kiev (2)	Kharkiv (3)	Dnepropetrovsk (4)	Odessa (5)
Lviv (1)	0	478,2	540,9	475,3	476,4
Kiev (2)	478,2	0	1008,7	712,2	216,9
Kharkiv (3)	540,9	1008,7	0	795,6	1014,7
Dnepropetrovsk (4)	475,3	712,2	795,6	0	482,3
Odessa (5)	476,4	216,9	1014,7	482,3	0

Table 2. The input matrix routes of supplies to the branches of the company's products "EVERLONG"

City – points of departure/destination	Lviv (1)	Kiev (2)	Kharkiv (3)	Dnepropetrov sk (4)	Odessa (5)	Altogeth er	Leaving the city
Lviv (1)	0	1	1	1	1	4	1
Kiev (2)	1	0	1	1	1	4	1
Kharkiv (3)	1	1	0	1	1	4	1
Dnepropetrovsk (4)	1	1	1	0	1	4	1
Odessa (5)	1	1	1	1	0	4	1
Altogether	4	4	4	4	4	20	
Leaving the city	1	1	1	1	1		

Table 3. The matrix of optimal routes of supplies to the branches of the company's products "EVERLONG"

City – points of departure/destination	Lviv (1)	Kiev (2)	Kharkiv (3)	Dnepropetrov sk (4)	Odessa (5)	Altogeth er	Leaving the city
Lviv (1)	0	1	0	0	0	1	1
Kiev (2)	0	0	1	0	0	1	1
Kharkiv (3)	0	0	0	1	0	1	1
Dnepropetrovsk (4)	0	0	0	0	1	1	1
Odessa (5)	1	0	0	0	0	1	1
Altogether	1	1	1	1	1	5	
Leaving the city	1	1	1	1	1		

Table 4. Matrix runs transport (km) in accordance with the optimal route of deliveries to the branches of the company products "EVERLONG"

City – points of departure/destination	Lviv (1)	Kiev (2)	Kharkiv (3)	Dnepropetrovsk (4)	Odessa (5)	Altogether
Lviv (1)	0	540,9	1008,7	1014,7	795,6	
Kiev (2)	540,9	0	478,2	476,4	475,3	
Kharkiv (3)	1008,7	478,2	0	216,9	712,2	
Dnepropetrovsk (4)	1014,7	476,4	216,9	0	482,3	
Odessa (5)	795,6	475,3	712,2	482,3	0	
Altogether	795,6	540,9	478,2	216,9	482,3	2513,9

According to the carried out calculations in the case of significant changes in the routes of the transportation path is reduced by 1968,6 km. This means that the savings of transportation costs between branch offices can reach 44%. The route is considerably reduced, it becomes more rational (Fig. 2).

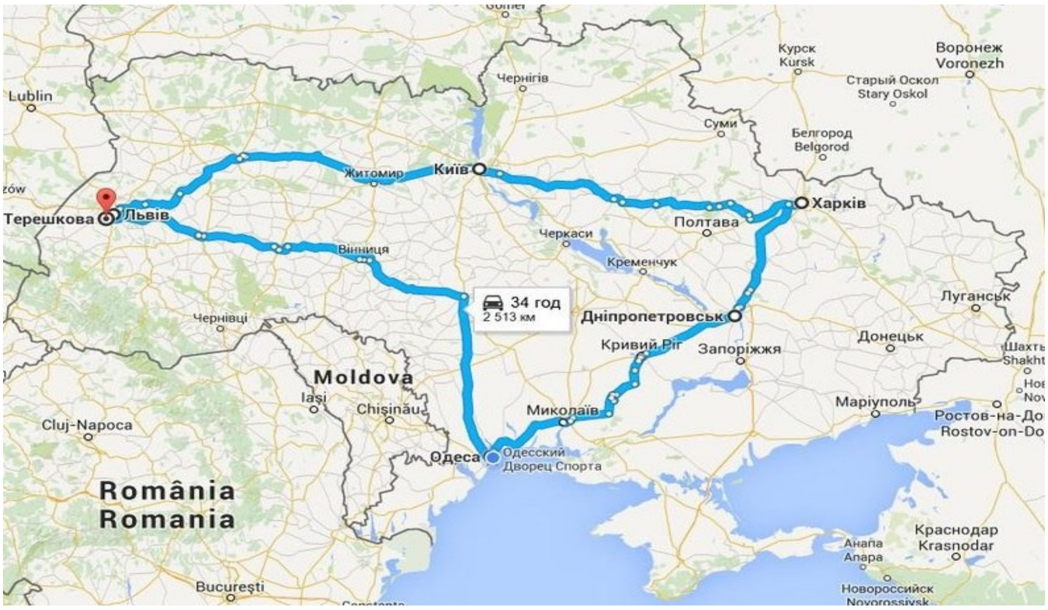

Fig. 2. The optimized route of the transport of goods in the company "EVERLONG"

The carrier won't go into the city twice, and distributes commodity products with regard to the needs of branches. This saves a considerable amount of time and resources. It should also be noted that in case of realization of such redevelopment of the logistic chain will not need to hire additional workers to service the transportation needs of long-distance shipping.

Delivery schedule of products from abroad – weekly. Additional calculations of the costs of transportation before and after optimize the supply chain, prove that the economic effect is approximately 49112 UAH on one truck.

To optimize the internal logistics chain (the movement of goods between warehouses of affiliates and contractors) used the model of the transport network.

In the present logistic system for the branches requires significant improvements. Deliveries are made according to the terms specified in customer volumes. At the same time, the shipping should be reasonable. All trucks must be optimally loaded, and warehouses must be required for the marketing of a number of products. In other words spending should be rational. But this becomes a problem for the company, considering the sharp rise in prices of fuel and lubricants, spare parts, rental stores, etc.

At the moment the company spends for transportation of goods to the counterparties a fixed amount, which is calculated according to the indicators of previous years during the same period, with some amendments. But this approach does not allow freedom to plan the expansion of its activities. Hampered by the lack of accuracy in the forecasts. This is also reflected on the value of the goods. With the expansion of the company the transport costs will rise and to predict the necessary level of financial security will be very difficult, which may sooner or later impact negatively on pricing policy, and therefore on competitiveness.

Thus, it is necessary to create a model that would give an effective picture of the resource use system of delivery of goods.

General formulation is as follows [10].

We introduce the following notation:

a_i – a stock of products ready for shipment in paragraph i (storage);

b_j – the need for the product in paragraph j (contractors);

v_{ij} – the cost of transporting per unit product from i to j (tariffs);

x_{ij}– the volume of traffic from i to j (unknown task).

Then, the model has the form:

$$\sum_{i=1}^{m}\sum_{j=1}^{n} v_{ij}\ x_{ij}\ \rightarrow \min$$

$$\sum_{j=1}^{n} x_{ij} \le a_i,\quad i=\overline{1,m}$$

$$\sum_{i=1}^{m} x_{ij} \ge b_j,\quad j=\overline{1,n}$$

$$x_{ij} \ge 0;\ i=\overline{1,m},\ j=\overline{1,n}$$

The model will demonstrate on the example of the Lviv branch of the company.

Available three storage and shipment (storage) and 9 contractors – "Silpo", "Furshet", "Tavria B", "Auchan", "Metro cash & carry", " Barvinok", "Arsen", "Vine Spot № 1", "Vine Spot № 2". Known the cost of renting storage and salary expenses staff.

In general, to ensure storage and transportation of goods in the city of Lviv, the company excels 96890,76 UAH/the month, of which 2623,76 UAH allocated costs for the transportation of the goods, and 35550 UAH. for wages of attendants on warehouses.

The cost of delivery of the freight unit from each origin to the respective destinations specified by the matrix of tariffs, UAH (table 5). The tariffs have been calculated on the basis of indicators of fuel consumption of the truck, its value at the moment and the distance that will overcome the carrier. In the matrix reflected the needs and the reserves estimated for the week.

As a result of calculations was obtained the following matrix of the optimal volume of traffic (unit of production.) – table 6.

Table 5. Tariffs for transportation of one product from the storehouse to the contractors for the city of Lviv (UAH)

The storehouse	COUNTERAGENTS									Needs (unit of production)
	1	2	3	4	5	6	7	8	9	
1	35,55	36,34	7,11	51,35	71,89	90,85	55,3	27,65	41,87	2630
2	66,36	67,94	62,41	90,85	14,22	48,19	85,32	54,51	36,34	3240
3	72,68	73,47	65,57	86,11	3,16	43,45	80,58	15,8	34,76	2290
Needs (unit of production)	890	720	1060	1530	1220	670	590	730	750	

Table 6. The optimal volume of deliveries of products from the storehouse (3 storehouse) to counteragents

The storehouse	COUNTERAGENTS									Needs (unit of production)
	1	2	3	4	5	6	7	8	9	
1	0	38 (1)	1058(1)	1528 (1)	0	0	0	0	0	2630
2	888 (1)	681 (1)	0	0	0	497 (1)	422 (1)	0	748 (1)	3240
3	0	0	0	0	1218 (1)	172 (1)	167 (1)	728 (1)	0	2290
Needs (unit of production)	890	720	1060	1530	1220	670	590	730	750	

For a correct calculation takes into account the fact that the counterparty is brought immediately the en-tire cargo and not one unit of production. The storehouses of the city of Lviv is served trucks Mitsubishi Fuso Canter 2002 with a load capacity of 5 tons and a fuel consumption rate of 19 l / 100 km. For one flight the carrier may deliver not more than 5,000 units of production. Therefore, despite the fact that whatever the number of products transported, counted only the number of trips a truck, in parentheses in the table indicated the number of flights. Thus, the optimal cost of shipping during the week are: $1{\cdot}66{,}36 + 1{\cdot}36{,}34 + 1{\cdot}67{,}94 + 1{\cdot}7{,}11 + 1{\cdot}3{,}16 + 1{*}\ 48{,}19 + 1{\cdot}43{,}45 + 1{\cdot}85{,}32 + 1{\cdot}80{,}58 + 1{\cdot}15{,}8 + 1{\cdot}36{,}34 = 490{,}59$ UAH.

Further analysis led to the abandonment of storehouse № 2 and the distribution of the respective volumes of the storage products between the other two storehouse. Held in the following circumstances optimal calculations proved the following traffic volumes to counterparties – table. 7.

Table 7. The optimal volume of delivery from storehouse (storehouse 2) to the counteragents

The storehouse	COUNTERAGENTS									Needs (unit of production)
	1	2	3	4	5	6	7	8	9	
1	890[1]	720[1]	1060[1]	1530[1]	0	0	590[1]	0	0	4790
3	0	0	0	0	1220[1]	670[1]	0	730[1]	750[1]	3370
Needs (unit of production)	890	720	1060	1530	1220	670	590	730	750	

The corresponding weekly cost of transportation was thus:
35,55 + 1·36,34 + 1·7,11 + 1·51,35 + 1·3,16 + 1·43,45 + 1·55,30 + 1·15,80 + 1·34,76 = 282,82 UAH.

Thus, due to the optimization it was assumed a considerable reduction of costs:
— monthly transportation costs will be 1131,28 UAH this is to 57 percent less costs to optimize;
— due to the refusal of store № 2 reduced the costs of rent and wages for storehouse workers;
— monthly costs for storage and transportation in the city decreased by 32105,48 UAH roughly 33 percent of the original amount.

Similar optimization calculations were carried out for all branches of the company [12], which proved a substantial reduction of costs of transportation and storage of products: the Odessa branches – 30%; in the Kharkov branch – 15%; Dnipropetrovs'k branch – 17%; in Kyiv – 1,5%. The latter proves that the Kyiv branch of the company operates near optimally.

Conclusions

Held on the presented models, the calculations show that optimization methods can be effectively used in the modern realities of the domestic economy. This allows the study company to not only best use of available resources, but also to determine the possibility of its further expansion.

The optimization effect is achieved by:
— route optimization transport: reduction of transport distances (there is no "loop"), transportation costs, decrease delivery time to the links of the distribution network;
— inventory optimization: more efficient organization of distribution storehouses and reduce storage costs and delivery of products to distributors.
— Optimize use of vehicles.

Thanks to the relatively efficient functioning of the market and trading company "EVERLONG" plans to significantly increase the list of partners and to develop the geography of cities delivery. To develop effective strategies for further development of the significant role played by the modeling element of the logistics network of the company. So in the future given the performances of the models must purchase additional modifications due to the emergence of new entities and counterparties of the company.

A promising direction for further research can be considered as well as analysis and modeling of the relationship of changes in logistics networks with the demand for the company's products in the relevant commodity market.

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