Cost Minimization by Lineer Shipping Transport Integration into the Supply Chain and Supplier Selection in a New Production Facility

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Abstract: As a result of liberalization and the globalization of international trade, factors of production and consumer products come from destinations around the world, and therefore the interdependence of supply chains between suppliers and wholesalers is increasing day by day. In this research, an optimization is carried out for the transportation in the supply chain, which aims to change route because of Russia and Ukraine war. The method is applied to the supply chain of a company that sells ready meals. This study aims to increase the competitive structure in the new market by reducing the cost of a fast food company that does not carry out maritime transport in its supply chain.

Keywords: cost minimization, lineer shipping, supplier selection, supply chain management

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1. Introduction

As a result of liberalization and the globalization of international trade, factors of production and consumer products come from destinations around the world, and therefore the interdependence of Supply Chains between suppliers and wholesalers is increasing day by day.

The effectiveness of Supply Chains has also become very important for proper competition in international markets that have emerged with the removal of trade barriers between countries. In this study, it is aimed to reveal the characteristics, processes, functions and development of Supply Chains and Supply Chain Management. Important definitions and theoretical analyzes of both Supply Chain and Supply Chain management are explained, transportation, which takes an important function of the supply chain, is discussed under a separate title, and information about the costs in the supply chain and their management are given.

Optimization of the supply chain includes the number and capacity of production sites, factories, distribution centers, transportation vehicles, warehouse locations and facilities. Structuring the supply chain is a strategic and long-term decision, so it has a significant impact over time. It largely defines more operational aspects such as means of transport, its features and capabilities. In addition, the industrial ecology approach to achieve sustainable development includes supply chains.

The analysis of the supply chain, which includes all its actors, must meet requirements such as meeting customer demands under constraints such as the delivery capacity of suppliers, the production capacity of factories, and the storage capacity of distribution centers. This requires complex processing of a large number of variables, which requires resorting to optimization to achieve optimal results, both to speed up the process and to ensure sufficient precision.

Suppliers, production facilities, distribution facilities, storage facilities, collection and recovery facilities are the members that make up the supply chain, and the supply chain is a dynamic process that includes the continuous flow of materials, funds and information across many functional areas within and between these members.

Entering a market of large wholesalers and supermarket chains has increased competition at the expense of small farmers. About 30-35% of total food produced is wasted each year due to inadequate infrastructure and ineffective supply chains. Globalization has also led to a collapse in biodiversity and ecosystems, obesity and increased food poverty, and the impossibility of consumers knowing enough about food source and quality.

However, consumers today are increasingly aware of the negative impacts of a globalized food system and are eager to reconnect directly with farmers, support local communities, consume healthy food. In addition, global food demand is projected to increase by 50% by 2030, leading to increased demand for resources for production and transportation.

Planners, stakeholders and researchers wonder if we will have enough healthy food in the future, and at what cost. For this reason, companies, especially in food supply chains, need to be faster, cheaper and more flexible than their competitors in order to meet customer expectations, as well as apply sustainable paradigms. When all these conditions are taken into consideration, both producers and farmers will benefit economically by purchasing the raw materials directly from the farmers and eliminating them from the intermediaries in the food supply chain. Thanks to the fresh and natural raw materials taken directly from the farmer, the harms of the products to human health will be reduced. By collecting back the used products from the end customer, the harm of wastes to the environment will be prevented and economic benefit will be provided by recycling the products.

In this research, an optimization has been carried out for the transporting in the supply chain, which aims to change route because of Russia and Ukraine war. The proposed model to define the optimal configuration allows decision making from raw material suppliers to possible distribution centers to the customer. This optimization was applied on the supply chain of a company selling ready-cooked food. Our study proposes to go further by interweaving for the several parameters which is possible suppliers and transportation costs.

2. Literature Rewiev

Govindan et al. [1] proposed a multi-objective optimization model by integrating sustainability into decision-making about distribution in a perishable supply chain network. Sustainable supply chain network design and a time windowed two-stage location orientation problem are used to optimize economic and environmental objectives in a perishable food supply chain. Soysal et al. [2] developed a multi-objective linear programming model to minimize the total logistics cost and to minimize the total amount of greenhouse gas emissions from transportation operations in a general cattle logistics network problem.

To reduce post-harvest loss (PHL) in supply chain networks, Nourbakhsh et al. [3] proposed a mathematical model that identifies optimum logistics for grain transport and infrastructure investment by identifying optimal locations for new pre-processing plants and optimizing road/rail capacity expansion. Bortolini et al. [4] proposed a three-target supply chain network to tackle the tactical optimization of fresh food distribution networks, taking into account operating cost, carbon footprint and delivery time objectives. A real case study of the distribution of fresh fruit and vegetables from a number of Italian producers to several European retailers was used to validate the applicability.

Allaoui et al. [5] made stakeholder selection using a hybrid multi-criteria decision-making method based on the Analytical Hierarchy Process (AHP) method and the Ordinary Weighted Average (OWA) aggregation method in the first stage. developed a mathematical model. The feasibility and efficiency of the model is demonstrated by the case of an agri-food company.

Rohmer et al. [6] developed a new network design that addresses sustainability issues in the context of the global supply chain. He illustrated trade-offs between alternative production and consumption scenarios, as well as conflicting goals, through a nutritional case study. Darestani and Hemmati [7] proposed a supply chain network model for perishable goods while considering the uncertainties associated with spoilage. The proposed model includes two sub-objectives, minimizing total grid costs and minimizing greenhouse gas emissions. General weighting method and Torabi-Hassini method were used to solve the dual-objective model.

Pourmohammadi et al. [8] developed a mixed integer linear mathematical model for wheat supply chain redesign and planning in Iran, which takes into account the differences between long-term and short-term storage facilities and wheat quality. Mohammadi et al. [9] proposed a multi-purpose model to design the supply chain in the processed food industry with products. Among the objectives of the model are profit maximization as an economic index, carbon dioxide emissions in the manufacturing sector and maximizing the number of jobs created as an environmental and social index by the wastewater treatment index.

Jouzdani and Govindan [10] developed a multi-objective mathematical model, taking into account the "Triple Bottomline Approach" of sustainability, to optimize cost, energy consumption and traffic congestion in the supply chain of perishable food products. Product lifetime uncertainty is modeled as a Weibull random variable and it is assumed that food perishability is affected by the use of car refrigerators, which is considered a decision variable. The study concluded that an economic compromise of 15% can increase the sustainability of the supply chain network design by 150%.

3. Case Presentation and Problem

Nimo is an active and developing company that has been in the Ukrainian market since 1942. In the Food and Ready Meal sector, Nimo works with companies that it exports to 7 countries, raw material suppliers from 3 countries, and about 30 different store chains where its products are sold in the domestic market.

It processes raw materials it has supplied from its suppliers. The company has a large store for wholesale plasters, chains of Ukrainian stores selling its own products. It has a warehouse to store the products it produces in Ukraine, a processing in facility, raw material and semi-raw material warehouses. It supplies raw materials for its products mainly from Russia. It also imports 55% of the final product to Russia. The company wants to develop its market network since 2013. With the Russia-Ukraine crisis, the company wants to expand to Europe and plans to establish a production facility in Europe. The work contents planning a route and choosing a supplier with the data we receive from the company. Because Nimo will open a new production facility in Europa and distribution will be provided from there.

The company plans to establish a new production facility in Albania. For this reason, it has started to search for new suppliers and markets. It receives its products and supply raw materials by land transport. However, it wants to be competitive in the European market and to have a place in the market share with competitive prices with using sea transportation.

Interaction with counterparties in the supply network on behalf of the company is established as follows: A report is created on the success of the supplier in certain positions and based on this it is decided whether to reorder a particular product from a supplier. If a positive decision has been made, the purchasing department creates an order, which is then sent to the suppliers. According to the information they have given us, there is no problem regarding the possible suppliers and their countries in terms of quality and shelf life. For this reason, with the information and cost information given in this study, a choice will be made in terms of planning a route and supplier in sea transportation.

A study will be made for a container routing and empty container routing with the given cost coefficients. The suppliers used by the company with land transportation are as follows.

a) Romania

b) Ukraine

c) Poland

The company related to the above suppliers has done a study and sent us the cost of 50.000 over the coefficients. If the result is less than 50,000 in our study, it has been reported that working with LS reduces the cost and a decision will be made in this direction. While calculating the cost coefficients, they evaluated the raw material price and the data received

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from LS companies within the scope of confidentiality and gave them to us by establishing this numerical connection between them.

Our work will take place in the following 2 stages. Stages are;

a) Testing possible supplier routes between containers loaded with raw materials and determining their costs (Row material)

b) Determining cost of containers loaded with final products

4. Mathematical Model

Notations are presented in Table 1 to facilitate the presence of notation marks.

TABLE I. NOTATIONS

Parameters	
c^s_{ij}	The cost of sending an empty container of type s over the service network from node i to node j (i,j)
c^k_{ij}	The cost of sending a unit of commodity k over the service network from node i to node j (i,j)
d^k	The demand quantity for commodity k
u_{ij}	The vessel capacity over the service network from node i to node j (i,j)
M	Sufficiently large non-negative number
N	Number of nodes in service network
Decision Variables	
γ^s_{ij}	Amount of empty container flow of type s over the service network from node i to node j (i,j)
ξ_k	Amount of artificial flow for commodity k
x^k_{ij}	Dual variable associated with constraints
Sets	
A	Set of service arcs in Graph G
N	Set of service nodes in Graph G
N^d	Set of destination nodes (Commodity or Empty container) in Graph G
N^o	Set of origin nodes (Commodity or Empty container) in Graph G
K	Set of commodities sent over the service network in Graph G
S	Set of empty container types i.e., foldable containers folded as s=1, s=2 or s=3 containers (Only empty containers
Miscellaneous	
i	A node of service network in Graph G
j	A node of service network in Graph G
k	A commodity
O^k	Origin node of commodity K
D^k	Destination node of commodity K
G = (N,A)	Graph representing the liner shipping network

The mathematical formulation of Laden and foldable Empty Container routing Problem (LECP) can be given as follows.

$$z^* = \min \sum\sum c^k_{ij}x^k_{ij} + \sum\sum c^s_{ij}\delta^s_{ij} + \sum M\xi^k \quad (1)$$

s.t

$$\sum x^k_{ij} - \sum x^k_{ji} + \xi^k = d^k \qquad \text{if } i = O^k;\ \forall k \in K \quad (2)$$

$$\sum x^k_{ij} - \sum x^k_{ji} - \xi^k = -d^k \qquad \text{if } i=D^k;\ \forall k \in K \quad (3)$$

$$\sum x^k_{ij} - \sum x^k_{ji} = 0 \qquad \forall i \in N \setminus \{O^k,D^k\},\ \forall k \in K \quad (4)$$

$$\sum x^k_{ij} + \sum \delta^s_{ij} \le u_{ij} \qquad \forall (i,j) \in A \quad (5)$$

$$\sum\sum s(\delta^s_{ji} - \delta^s_{ij}) - \sum\sum (x^k_{ij} - x^k_{ji}) \ge 0 \qquad \forall i \in N \quad (6)$$

$$x^k_{ij} \ge 0\ \forall (i,j) \in A, \qquad \forall k \in K \quad (7)$$

$$\delta^s_{ij} \ge 0\ \ \forall (i,j) \in A, \qquad \forall s \in S \quad (8)$$

$$\xi^k \ge 0 \qquad \forall k \in K \quad (9)$$

5. Application

There is no need for cold chain application for raw materials. For this reason, the containers we use can be used as laden and foldable containers. The model was used in the same form for supplier selection.

1st possible 3 supplier countries are as follows;

a) Spain

b) Tunisia

c) Belgium

The information required for the model is shown in Tables 2-4.

TABLE II. ARCS AND COST COEFFICIENT FOR 1ST SCENARIO

Origin (Node i)	Destination (node j)	Cost Coefficient
Belgium	Spain	38
Spain	Tunisia	20
Tunisia	Albania	13
Belgium	Tunisia	45
Albania	Belgium	54

TABLE III. COMMODITIES ORIGINS AND DESTINATIONS FOR 1ST SCENARIO

Commodity	Origin (node i)	Destination (node j)
Raw Material 1	Belgium	Albania
Raw Material 2	Spain	Albania
Raw Material 3	Tunisia	Albania

TABLE IV. COUNTRIES AND CONTAINER DEMANDS FOR 1ST SCENARIO

Country	Container Demands
Belgium	200
Spain	200
Tunisia	200
Albania	600

Using given information above, the optimal solution of objective function is 13.950.

2nd possible 3 supplier countries are as follows;

a) Portugal

b) Morocco

c) Italy

The information required for the model is shown in tables 5-7.

TABLE V. ARCS AND COST COEFFICIENT FOR 2ND SCENARIO

Origin (Node i)	Destination (node j)	Cost Coefficient
Portugal	Morocco	7
Morocco	Italy	24
Italy	Albania	5
Morocco	Albania	30
Albenia	Portugal	33

TABLE VI. COUNTRIES AND CONTAINER DEMANDS FOR 2ND SCENARIO

Commodity	Origin (node i)	Destination (node j)
Raw Material 1	Portugal	Albania
Raw Material 2	Morocco	Albania
Raw Material 3	Italy	Albania

TABLE VII. COUNTRIES AND CONTAINER DEMANDS FOR 2ND SCENARIO

Country	Container Demands
Portugal	200
Morocco	200
Italy	200
Albania	600

Using given information above, the optimal solution of objective function is 11.950.

3rd possible 3 supplier countries are as follows;

a) Denmark

b) Portugal

c) Tunisia

The information required for the model is shown in tables 8-10.

TABLE VIII. ARCS AND COST COEFFICIENT FOR 3RD SCENARIO

Origin (Node i)	Destination (node j)	Cost Coefficient
Denmark	Portugal	40
Portugal	Tunisia	23
Tunisia	Albania	13
Albania	Denmark	59

TABLE IX. COUNTRIES AND CONTAINER DEMANDS FOR 3RD SCENARIO

Commodity	Origin (node i)	Destination (node j)
Raw Material 1	Denmark	Albania
Raw Material 2	Portugal	Albania
Raw Material 3	Tunisia	Albania

TABLE X. COUNTRIES AND CONTAINER DEMANDS FOR 3RD SCENARIO

Country	Container Demands
Denmark	200
Portugal	200
Tunisia	200
Albania	600

Using given information above, the optimal solution of objective function is 15.750.

Based on the above optimizations, the lowest cost route is the route in scenario 2. Row material 1 supply from Portugal, row material 2 supply from Morocco, Row material 3 supply from Italy. This selection is give us 25% cost saving according to worst scenario.

6. Discussions and Conclusions

As a result of the processes we have done above, the supplier country has been selected, as well as the routing of possible routes for the market. The results we found are as follows.

1st possible 3 supplier countries and cost coefficient are as follows;

a) Spain

b) Tunisia

c) Belgium

We found 13.950 cost coefficient using Gams for LECP.

2nd possible 3 supplier countries and cost coefficient are as follows;

a) Portugal

b) Morocco

c) Italy

We found 11.950 cost coefficient using Gams for LECP.

3rd possible 3 supplier countries and cost coefficient are as follows;

a) Denmark

b) Portugal

c) Tunisia

We found 15.750 cost coefficient using Gams for LECP.

The supplier countries we chose in the light of the information above are Portugal, Morocco, Italy. This choice gave us approximately 25% cost savings over the worst-case scenario. Later, when we did this study for the market, we found 26.950 cost coefficient.

When the choices and transportation we described above are used, a total cost is 38.900 cost coefficient. The company informed that if land transportation is used, there will be

50.000 cost coefficient. In this direction, we have achieved approximately 22.2% cost savings with our work.

Supply chain is the general expression of the system of producing and delivering a product or service from the very beginning of the procurement of raw materials to the final delivery of the product or service to the end consumers. The supply chain is a set of processes that encompasses all aspects of the manufacturing process, including the activities involved at each stage, the information transmitted, the natural resources converted into useful products, human resources, and other components that go into the finished product or service. Businesses have to optimize their supply chains in order to maintain their cost and market advantage by delivering quality products and services to the end consumer as soon as possible and at the desired time. The increase in global trade at this level has been an inevitable result of minimizing transportation costs in order to reduce the cost for exporting countries. Increasing fuel costs in the global have put great pressure on the cold chain. For this reason, maritime transportation has become the number one point for cost reduction. Containerization of frozen commodities is steadily progressing, while bulk reefers retain a significant market share, particularly for certain commodity flows. With the spread of containerization, the competition between frozen bulk and container becomes increasingly intense. More academicians are focusing on this area, while business leaders are looking for practical tools to help them with their daily operations and decision-making.

Increasing fuel prices in the world have caused a great cost increase in supply chains. For this reason, the use of more economical transportation lines has gradually increased. Along with rising fuel prices, the amount of fuel used is constantly harming our planet. In addition to cost optimization, this study was also carried out in terms of sustainable engineering and green engineering concepts. A green planet is the greatest gift we can give to future generations.

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