COST MINIMIZATION BY LINER SHIPPING TRANSPORT INTEGRATION INTO THE SUPPLY CHAIN AND SUPPLIER SELECTION

(TEDARİK ZİNCİRİNE DENİZ TAŞIMACILIĞI ENTEGRASYONU İLE MALİYET MİNİMİZASYONU VE TEDARİKÇİ SEÇİMİ)

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Ahmet KARAKAYA, B.S.

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LIST OF SYMBOLS

LECP: Laden and foldable Empty Container Routing Problem

LS: Liner Shipping

TBL: Triple Bottom Line

PSO: Particle Swarm Optimization

AHP: Analytical Hierarchy Process

OWA: Ordinary Weighted Average

SSDS: Sailing Schedule Design Problem

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ABSTRACT

As a result of the globalization of international trade, factors of production and consumer products come from different destinations around the world. Therefore, the interdependence of supply chains between suppliers and wholesalers is increasing day by day. This study aims to minimize transportation costs. The study explains important definitions for the supply chain and gives information about the costs in the supply chain and their management. Transportation costs, which take an essential function in the supply chain, are given under a separate title. 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 numerous variables, which needs resorting to optimization to achieve optimal results, both to speed up the process and to ensure sufficient precision. This research has been performed optimization for transportation of a supply chain, which aims to change route because of the Russia and Ukraine war. The proposed model defines the optimal configuration. In addition, it allows to decide raw material suppliers, possible distribution centers and the possible customers. Our study aims to increase the competitive structure in the new market by reducing the cost of a fast-food company that does not perform maritime shipping in its supply chain. Adding liner shipping to the supply chain would reduce the cost of transporting raw materials. The supply chain will use maritime shipping instead of land transportation. Since there is less fossil fuel per unit in shipping, both the cost and the carbon emissions will be reduced. As regards its sustainability and its contribution to the environment, shipping is the most appropriate solution. The originality of the study is the use of foldable containers using in the cold chain. Including maritime shipping leads to sustainable engineering and cost reduction. The raw material will be shipped in an empty and foldable container within this study. Since the final product shipment requires a cold chain, the folding container will not be used at this point. Certain

coefficients for the container average are drawn from company authorities. With these coefficients, the choice of raw material suppliers and cost optimization for the market was found by solving the mathematical model of the Laden and Foldable Container routing Problem with the GAMS software.

ÖZET

Uluslararası ticaretin liberalleşmesi ve küreselleşmesinin bir sonucu olarak, üretim faktörleri ve tüketim ürünleri dünyanın dört bir yanındaki varış noktasına gelmekte ve bu nedenle tedarikçiler ve toptancılar arasındaki Tedarik Zincirlerinin karşılıklı bağımlılığı her geçen gün artmaktadır. Bu çalışmada Tedarik Zincirleri ve Tedarik Zinciri Yönetiminin özelliklerini, süreçlerini, işlevlerini ve gelişimini ortaya koymak amaçlanmıştır. Hem Tedarik Zinciri hem de Tedarik Zinciri yönetiminin önemli tanımları ve teorik analizleri açıklanmakta, tedarik zincirinin önemli bir işlevini üstlenen taşımacılık ayrı bir başlık altında ele alınmakta ve tedarik zincirindeki maliyetler ve maliyetlerin yönetimi hakkında bilgi verilmektedir. Tedarik zincirinin tüm aktörlerini içeren tedarik zincirinin analizi, tedarikçilerin teslimat kapasitesi, fabrikaların üretim kapasitesi, dağıtım merkezlerinin depolama kapasitesi gibi kısıtlar altında müşteri taleplerinin karşılanması gibi gereksinimleri karşılamalıdır. Bu hem süreci hızlandırmak hem de yeterli kesinliği sağlamak için optimal sonuçlara ulaşmak için optimizasyona başvurmayı gerektiren çok sayıda değişkenin karmaşık işlenmesini gerektirir. Bu çalışmada Rusya ve Ukrayna savaşına bağlı olarak yeni tedarikçi ve Pazar arayışına giren bir firmanın tedarikçi seçimi yapılacaktır. Optimal konfigürasyonu tanımlamak için önerilen model, malzeme tedarikçilerinden olası dağıtım merkezlerine ve muhtemel pazara karar vermeyi sağlar. Bu optimizasyon, hazır yemek satan bir şirketin tedarik zincirine uygulanmıştır. Çalışmamız, tedarik zinciri içerisinde deniz taşımacılığı yapmayan bir hazır gıda firmasının deniz taşımacılığı ile maliyetini düşürerek yeni gireceği pazardaki rekabetçi yapısını artırmayı hedeflemektedir. Tedarik zincirine hat taşımacılığı eklenerek hammadde taşıma maliyeti düşürülecektir. Tedarik zincirinde kara taşımacılığı kullanımı yerine deniz taşımacılığı kullanılacaktır. Deniz taşımacılığında birim başına kullanılan fosil yakıt daha az olduğu için hem maliyet azaltılacak hem de karbon salınımı azaltılacaktır. Sürdürülebilir olması ve çevreye katkısı bakımından deniz taşımacılığı kullanımı en uygun çözümdür. Soğuk zincir içerisinde katlanabilir boş

konteyner kullanılması ve deniz taşımacılığının dahil olması ile hem sürdürülebilir bir mühendislik çalışması hem de azalan maliyetlerin ortaya konulması çalışmanın özgünlüğüdür. Bu çalışma dahilinde hammadde, boş ve katlanabilir konteyner ile taşınacaktır. Nihai ürün taşımasında soğuk zincir kullanılması gerektiği için burada katlanabilir konteyner kullanılmayacaktır. Konteyner rotalama için belirli katsayılar şirket yetkililerinden alınmıştır. Bu katsayılar ile hammadde tedarikçi seçimi ve pazar için bir maliyet optimizasyonu boş ve katlanabilir konteyner rotalama (LECP) matematiksel modelinin GAMS programıyla çözülmesi ile bulunmuştur.

1. INTRODUCTION

Along with liberalization and the globalization of international trade, producer and consumer goods come from different destinations across the globe. For that reason, the interdependence of Supply Chains between suppliers and wholesalers increases every day. The efficacy of Supply Chains has also become crucial for fair competition in international markets that have emerged with the removal of trade barriers between countries. This study 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 were explained. Transportation takes an important function of the supply chain. It was addressed under a separate title. And information on the costs of the supply chain and management of supply chain costs were provided (Apaiah and Hendrix, 2005).

Optimization of the supply chain includes the number and capacity of production sites, factories, distribution centers, means of transportation, 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 transportation, their features, and capabilities. Besides, it includes the industrial ecology approach to achieving sustainable development of supply chains.

The analysis of the supply chain includes all the supply chain actors. It 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. And this requires complex processing of a large number of variables that must be used to obtain optimal results, for optimization, which is performed both to speed up the process and to provide sufficient precision (Zhalechian et al., 2016).

Distribution facilities, suppliers, storage facilities, production facilities, collection, and other facilities are the members comprising the supply chain. And the supply chain is a dynamic process including the continuous flow of materials, cash, and feedback across many functional areas between these members (Barsing et al., 2018).

Determining the number, location, and capacity of supply chain members and the flow between them is called Supply Chain Management. The dynamics of supply chain management have changed over the years, and new paradigms have been added to supply chain management in order to respond to increasing environmental pollution and third parties' (costumer, legal regulations, etc.) pressures. Increasing environmental concerns, the impact of global warming, social-environmental concerns, legal regulations of organizations and governments, and decreasing raw material resources and profit margins have increased the importance of sustainability (Liu et al., 2019). In this process, the supply chain has turned into a cyclical and sustainable structure through the collection of used products from end-users. With this transformed structure, concepts such as "Closed-Loop Supply Chain Management" and "Sustainable Supply Chain Management" have emerged. As a consequence of the increase in environmental awareness and the importance of sustainability, the concept of the Sustainable Supply Chain has started to attract more attention from academics and practitioners. This structure, Sustainability, Triple Bottomline (TBL Approach) in the literature, is defined on three main pillars: economic, environmental, and social factors. Recent research shows that the integrated use of sustainable tools and methods creates cooperation in organizations, and simultaneously, improves both operational and environmental performance. In fact, this is not surprising. Because one of the most popular economic paradigms used for continuous improvement, the waste reduction (material, water, energy, and so forth), which is one of the main objectives of Lean Production, directly overlaps with the green philosophy. Globalization has a significant impact on ready-to-serve food. Direct relations between raw material producers and consumers have been changed by a complex system that includes various materials.

Entering the large wholesalers' market and supermarket chains market has increased competition at the expense of small farmers. About 30-35% of the 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 sources and quality (Bortolini et al., 2016). 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, and eat healthier. In addition, global food demand is projected to increase by 50% until 2030, leading to increased demand for production and transportation resources. 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 to meet customer expectations and apply sustainable paradigms. Considering all these conditions, producers and farmers will benefit economically by purchasing the raw materials directly from the farmers and by eliminating them from the intermediaries in the food supply chain. Thanks to the fresh and natural raw materials taken directly from the farmer, the harm of the goods to human health will be reduced. By collecting back used products from the end customers, the harm of waste to the environment will be prevented and economic benefit will be provided by recycling the products.

In this research, an optimization plan has been developed for supply chain transporting, which aims to change route due to the Russia and Ukraine war. The recommended model to determine the optimal configuration sheds light on the decision-making process from raw material suppliers to possible distribution centers to the customer. This optimization was implemented for the supply chain of a company selling ready-to-serve food. Our study suggests going further by integrating various parameters that would potentially be available to suppliers and transport costs.

2. LITERATURE REVIEW

As reported by research (Chase and Jacobs, 2014), the Supply Chain refers to transferring information and materials by origin and destination in manufacturing processes, including logistics and warehousing processes. Procurement refers to the shipment of goods and services to factories and warehouses at one end of the chain while to customers at the other.

Another research (Silva et al., 2009) worked on supply chain management using optimization. This work introduced a new supply chain management methodology based on the total modeling of the supply chain, logistics, and distributors, consisting of suppliers, as a distributed optimization problem. Various operational activities were solved by a meta-heuristic optimization, which is called an ant colony, which allows information to be exchanged between different optimization problems through a pheromone matrix. The simulation results reveal that the new methodology is more capable than the simple decentralized methodology for disparate instances of the supply chain.

Supply Chain Management involves making various decisions. The term Building Decisions refers to the distribution centers and location of factories or warehouses, the number and capacity of facilities, the capacity to outsource or expand, and the means of transportation to be used (Silver et al., 1998).

The result of structuring decisions is known as the configuration of the supply chain. The configuration of the supply chain itself is a hypercritical decision variable. Because the implied decisions such as the location of storehouses, interconnection policies, distribution of companies, and fund levels are extremely important to supply chain systems (Hopp and Spearman, 2001).

A study (Kheljani, et al., 2009) discussed the coordination issue between a buyer and over one potential supplier during the supplier choice process. Moreover, the model aims to minimize the total cost of the supply chain, not just the cost of the buyer. The total cost of the supply chain includes all the costs related supply chain, such as costs of the buyer and the costs of suppliers. The mixed-integer non-linear programming was performed to solve the model.

Wang and Shi (2011) presented a multi-objective optimization model for the design of a supply chain configuration. The modeled configuration extends from suppliers to product collection centers. However, customers in distribution centers do not include intermediate storage. In the objective function, total costs and equivalent carbon emissions were minimized. The decision variables are the location of the actors and the transportation of both materials and the final product, and recycling to close the loop. Returned product demands and rates were studied with uncertainty. Thus, individual scenarios were examined. The weighting factor was used in order to analyze each target. Accordingly, it highly affected the results in both economic and environmental aspects. Hence, careful estimation of its value was recommended.

Ramuhidin et al., (2008) introduced an optimization model for a supply chain design solved by mixed-integer linear programming. The modeled configuration ranges from suppliers to customers but does not include distribution centers. The model analyzes the impact of the means of transportation and the number of transfers. Decision variables are the location of the facilities, means of transportation, and the number of transfers made. They formulated one of the total costs and one of the carbon emissions as objective functions. In the carbon emission function, the maximum allowable emission limit in the chain is accepted. As a consequence, as interest in environmental protection decreased, more trips were made to longer distances. A balanced solution was found using goal programming.

Another research (Davis and Doyle, 2011) revealed a supply chain optimization, a decision framework that guides financially responsible decisions. A cost-effective supply chain was driven by applying a cost analysis process to product selection. It includes product sourcing solutions to reduce procurement costs, improve logistics efficiency to eliminate unnecessary processes, and inventory management to ensure product availability. The cost analysis approach was an analytical product selection methodology that included product evaluation and recommendations based on consideration of clinical benefit, the entire financial impact, and earning impact.

Gong et al., (2007) developed an inventory location-allocation model for supply chain network design to minimize the total inventory carrying cost of fresh agricultural products and waste in the supply chain. To raise the quality of the solution, a regional search is embedded in the Particle Swarm Optimization (PSO) algorithm. The results show that the algorithm can completely resolve the conflict between distinct costs and boost development decisions regarding Beijing's perishable ready-to-serve food distribution centers.

Jiang et al., (2009) produced a mixed-integer stochastic model for a flexible multi-supplier-based network design to increase the survivability and flexibility of the supply chain network after supply disruptions occur in a meat-food supply chain. To solve the suggested model, the benders decomposition algorithm is used. A case study was conducted for the applicability and accuracy of the model.

Akerman et al., (2010) explored quantitative operations management approaches to food distribution management and food distribution management-related challenges facing the industry. Three aspects of the literature, foodstuff quality and safety, and sustainability, are focused on at three decision levels: strategic network design, tactical network planning, and operational shipment planning.

Zhao and Lv (2011) developed a mixed-integer model to take plant location and production capacity chosen in the agricultural supply chain. As a result of the complexity of the design problem for a multi-tier and multi-product supply chain, the PSO algorithm is proposed.

Ogier et al., (2013) established a model which is mixed integer for fresh supply chain network design due to seasonality of supply, limitation of transfers for products, and no possibility of storage between consecutive periods.

Govindan et al., (2014) offered a multi-objective optimization model by integrating sustainability into decision-making about distribution in a decaying supply chain network. A sustainable supply chain network design and a time windowed two-level location orientation problem were used to optimize economic and environmental objectives in a decaying food supply chain.

Soysal et al., (2014) created a multi-objective linear programming model to minimize the total logistics cost and to minimize the total amount of greenhouse gas emissions from shipping operations in a general cattle logistics network problem.

Similarly, Cascini et al., (2014) developed a multi-purpose, multi-product, multi-layer, multi-period complex linear integer model to minimize both global cost and environmental impact in the fresh supply chain. The supply chain network design case study demonstrates the feasibility and accuracy of the suggested model.

To reduce a post-harvest loss (PHL) in the supply chain networks, Nourbakhsh et al., (2016) offered a mathematical model that identifies optimum logistics for grain transport and infrastructure fund by analyzing optimal spots for new pre-processing plants and optimizing road / rail capacity growth.

Marco Bortolini et al., (2016) suggested a three-target supply chain network that handles the tactical optimization of fresh-food distribution networks, considering carbon footprint, operating cost, and delivery time objectives. A real case study of the distribution of fresh foods from several Italian producers to certain European retailers was used to validate the applicability.

Colicchia et al., (2016) developed a multi-objective mathematical model for creating a supply chain network that is both efficient and ecologically sound. The applicability and accuracy of the proposed model are shown in a case study on the distribution of chocolate products by Lindt and Sprüngli. The results revealed that cost-oriented network optimization can have favorable effects on the environment and a minor increase in distribution costs can be offset by an enormous improvement in environmental performance.

Mohammed and Wang (2017) produced a multi-objective probabilistic model for a cost-effective meat supply chain design that aims to minimize the total transportation cost, the number of means of transportation, and the delivery time of meat products. The strength and applicability of the developed multi-objective model and offered solution methods are exposed to a case study.

Miranda-Ackerman et al., (2017) modeled multi-objective optimization of a three-stage green supply chain network comprising the supplier, production, and market levels. The feasibility and accuracy of the model were demonstrated by an orange juice supply chain case study.

Another study (Gholamian and Taghanzadeh, 2017) presented a model for integrated wheat products supply chain network design that includes long-term supplier selection decisions, placement of new silos, mid-term appointment, and distribution decisions of wheat and its products.

Allaoui et al., (2018) made stakeholder selection using a hybrid multi-criteria decision-making approach based on the Analytical Hierarchy Process (AHP) method, and the Ordinary Weighted Average (OWA) aggregation method in the first stage. They have developed a mathematical model. The feasibility and efficiency of the model were shown by an agri-food company case.

M. Bortolini et al., (2018) used two different packaging containers, disposable, and reusable, to increase sustainability. The costs and emissions of these packaging containers are naturally different. They developed a dual-purpose mixed linear integer programming model for fresh fruit and vegetable distribution chain network design to determine the best choice of packaging container, storage / processing node location, and flow distribution. The strength of the model was simulated by a real case from the Emilia-Romagna region of Italy.

Barsing et al., (2018) used a cross-docking center to reduce and eliminate the level of uncertainty, unpredictability, and complexity caused by short shelf-life and high diversity in the supply chain. They have developed a novel approach to selecting one of n cross-docking facilities based on material or information flow among stakeholders. Das (2019) has developed a sustainable supply network design model that combines flexible criteria, and lean and green-based practices to overcome the limitations of current supply chain practices that generate significant waste and emissions and improve their performance. The suitability of the model is exhibited by the grid network of a sample state.

Rohmer et al., (2019) developed a new network design that addresses sustainability issues in the sense of the global supply chain. They illustrated trade-offs between alternative production and utilization scenarios, with conflicting goals, through a nutritional case study.

Darestani and Hemmati (2019) proposed a supply chain network model for decayable goods while considering the uncertainties affiliated with spoilage. The recommended model consists of two sub-objectives, minimizing total grid costs and minimizing greenhouse gas emissions. The general weighting method and Torabi-Hassini method were used to solve the dual-objective model.

Ghanbari and Bashiri (2019) developed a two-stage stochastic model that considers outage scenarios for both suppliers and distribution centers to design a flexible agricultural supply chain. The results have proven that implementing flexible strategies for the supply chain will generate more profits and save costs.

Mohammadi et al., (2020) developed a mixed-integer linear mathematical model for wheat supply chain redesign and planning in Iran, which considers the differences between wheat quality and long-term and short-term storage facilities.

Mohammadi et al., (2020) proposed a multipurpose model to design the supply chain in the processed ready-to-serve 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.

Biuki et al., (2020) planned a two-step approach to incorporate the three dimensions of sustainability into supply network practices. In the first phase, they designed a multi-objective mixed-integer programming model to help plan a sustainable supply chain. In the second step, two-hybrid metaheuristic methods were used to solve the problem, namely the Genetic Algorithm (GA) and PSO algorithm, parallel and serial combinations.

Mogale et al., (2020) developed a bilateral decision support model for the sustainable food grain supply chain that aims to minimize the cost and carbon dioxide emissions at the same time. The model covers many problem concepts such as multistage, multi-period, multi-modal transport, multi-sourcing and distribution, emissions from various causes, heterogeneous capacity vehicles, and warehouses with limited availability and capacity.

Jouzdani and Govindan (2021) developed a multi-objective mathematical model, considering the “Triple Bottomline Approach” of sustainability, to optimize cost, energy utilization, and traffic congestion in the supply chain of perishable food products. Product shelf-life indistinctness 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 network design by 150%.

In addition to the above supply chain models, we are going to do linear shipping together with laden or empty container routing to minimize shipping costs. The literature view of empty container routing is as follows.

Container trade accounts for around 25.4% of the global dry cargo trade network and more than 61% of global seaborne dollar trade in 2018 (UNCTAD, 2018). While container transport was around 58 million TEUs in 2000, it reached 148 million TEUs in 2018 (UNCTAD, 2018). In 18 years, it showed growth in the volume of about 2.5 times. Over the years, liner shipping has become the cornerstone of shipping. This has created an excellent competitive environment for ocean shipping (see Fransco and Lee, 2013). Based on this competitive environment, the cost per container unit is low. A container receives almost as much material as a truck. It is the cheapest means of transportation per unit in comparison to air, land, and rail transport (Ateş et al., 2010).

Liner shipping companies compete primarily on cost due to the limited number of overhauls. Thus, liner shipping companies determine the service route at any given time on a shipping route, and this route is usually circular. It is expected to end where it began (Akyüz and Lee, 2016). Liner shipping studies, which compete on cost, aim to reduce costs. The size of vessels is noteworthy in terms of environmental impact and the cost of transporting containerized freight. Route network design has become more important for optimal capacity utilization with the larger vessel (Gelareh and Pisinger, 2011).

Most of the work on the planning of liner shipping services aims to develop a decision support tool by creating mathematical models to determine the best route by adding different constraints. As stated by Notteboom (2008), about 70-80% of ships have at least one late port between departures and returns. Common causes of these delays are severe weather, port strikes, port congestion, roads, mechanical breakdowns, and in rare cases, piracy activities and ship crew strike.

In recent years, the active competition of LS companies and the decline of the global maritime industry have caused LS companies to reduce their costs at the level of tactical planning by applying negative pressure on the profit share of LS companies (Wang and Meng, 2012). LS companies publish their service information before arranging their trips and their rates of return are largely determined (Wang and Meng, 2012). Fuel optimization, the main source of costs (49% according to MAERSK), is gaining importance. In cost minimization (Wang and Meng, 2013), an optimization model has been established.

In a study (Dirksen, et al., 2013), air opposition and other situations at the beginning of the routing plan prepare to avoid a deviation less than or equal to the delivery time of the cargo to be monitored at high speed in order to avoid excessive consumption of fuel intended to create a mathematical model. In this model, realistic constraints such as air opposition, freight delay cost, and fuel cost are added. In the event of an interruption, the head of the LS company decides on the measures to be taken against the situation. Another factor that LS companies face is the cost of freight delays. Although this cost cannot be objectively measured as fuel, it is the customer pick-up cost of delay in loading customers.

In another study related to fuel optimization (Wang and Meng, 2012), the Ship Sailing Schedule Design Problem (SSDS) developed a model that takes into account the uncertainties of the weather that the ship may experience, the sea, and the port. If LS companies reduce vessel speed to use less fuel, more vessels should be used within weekly service requirements. For this reason, this study developed a balanced model between the number of ships and the cost of fuel. And considering the reduction of ship and shelter costs for the routing technique, the design of the sea route plan uncertain transfer times, from one port to another, and the costs of cargo delays, a solution algorithm has been created.

In the case of simultaneous fleet distribution (Gelareh and Pisinger, 2011), additional constraints are flow and transfer stations in some regions. This model examined the problem of designing the service network for a fleet of ships. It aimed to maximize the utilization rate of the fleet of ships. The model considered whether freight forwarders want the cargo to be deployed in the distribution network or not even supplied. Moreover, regular service is assured, and this model is extremely flexible and expandable. The transfer cost was certainly considered in the model. In practice, global commercial transportation has a regional structure, such as Europe-North America, and Europe-Asia. Hence, a network model was designed for fleets of ships to service a region. The model is established as a linear schedule.

In a study on the use of navigation-related fuel optimization (Wang and Meng, 2011), historical company data were examined to determine the evolution of the amount of fuel consumed during navigation. In a study on the problem of cargo delays (Wang and Meng, 2012), the waiting period was limited due to uncertainties in port operation and obstruction. According to a survey (Drewry Shipping Consultants) of 5410 ship information, nearly half of the ships are behind schedule. In a study on the problem of determining the size of the fleet (Àlvarez, 2009), the problems of orientation and placement of a ship-fleet were addressed. He devised a mixed-integer program model for the joint solution of ship routes and distribution, determining the size of the fleet and its optimal utilization. Several types of vessels are authorized to be represented.

3 MATERIALS AND METHODS

3.1 SUPPLY CHAIN MANAGEMENT

Supply chain management is the process of supervising the transportation of raw materials, semi-products, and final products from the beginning of production to delivery to the purchaser. It controls the flow of goods and services within an organization. Besides, the management process includes planning, designing, executing, monitoring, and controlling supply chain activities to build net value, create a competitive framework, leverage global logistics, synchronize demand and supply, and measure achievement globally. Supply chain management is also a discipline of business and technological systems that refers to coordinating ways activities related to purchasing, designing, creating, and selling a product. These systems integrate suppliers, distributors, and specialized logistics businesses to develop the efficiency of production and distribution. Information flow in a supply chain is automated by technology to optimize the supply, production, and delivery of products or services to the end consumer. The term supply chain management is newly considered a term. It first emerged in the logistics literature in 1982 as an inventory management approach with the importance of raw material supply. In the 1990s, scholars first defined supply chain management from a theoretical perspective, clarifying that it has many different components, from more traditional approaches to supervising the flow of materials and related information (F. Wang et al., 2011). Studies on supply chain management emphasize the need for collaboration between successive actors, from the first producer to the final purchaser, in order to meet demand more effectively and at lower costs.

Supply chain management is a phenomenon focused on the management of relationships. Supply chain management is the integrated coordination, planning, and control of all activities and processes to provide superior consumer value at less cost to the supply chain overall, while satisfying the needs of other stakeholders in the supply chain. The so-called “value” is the amount purchasers are willing to pay for what an organization produces. The value created by a production activity is defined based on the cost of realizing it.

3.2 Supply Chain Planning

Planning is the fundamental element of the supply chain. Organizations cannot survive without proper strategy development and implementation. Planning includes the following stages (Liu et al., 2018).

a) Determination of how and when production inputs will be procured
b) Determination of the best production strategy to transform the material into the final product
c) Determination of the transportation method in the transportation of stocks
d) Effective establishment of the distribution network
e) Supply chain risk management planning
f) Taking measures to reduce costs without sacrificing quality
g) Establishment of an information flow system to facilitate information sharing

The above stages aim to establish a set of policies and procedures to manage material, information, and cash flows. The best way to understand general supply chain management logic is to look at the planning levels. These planning levels provide a logical understanding of supply chain management processes. Planning in the Chain consists of three levels:

Strategic planning: Frequently, this is called supply chain strategy. It is a high level of planning that needs long-term decision-making. The planning period is usually 3 to 10 years. It is the planning type that will constitute a basis for establishing policies and procedures for the organization’s long-term purchasing, production, and logistics and lay the foundation for the operational processes necessary for the efficient and effective operation of the entire supply chain. Decisions at this level are a critical component of supply chain management, as they affect significantly the overall organizational structure.

Decisions made at this level have wide-ranging effects such as determining and establishing how many distribution facilities and where they are needed in the future, performing corporate mergers and acquisitions to enlarge market share and supply chain structuring (Bechtel and Jayaram, 1997).

Tactical Planning: The strategic plan must be broken down into appropriate action steps to be feasible and achievable. Tactical planning comes into play at this point. Unlike strategic planning, tactical-level decisions usually cover a period of 6 months to a year. At this stage, the aim is to maximize effectivity in short-term operations, considering the decisions taken in strategic planning. In simple terms, short-term goals should create value to keep up the strategic direction of the companies. Tactical planning includes functions such as quarterly or semi-annual forecasts, measures to reduce stocks, selection of suppliers, and production schedules at the product line level (Bechtel and Jayaram, 1997).

Operational planning: These are the daily or weekly activities required to achieve tactical objectives. At this stage, activity control policies are integrated to ensure that day-to-day activities are optimized and create value. These are the most prominent processes seen in the day-to-day operations of the business. Tasks performed at this level include taking customer orders, production schedules at the end product level, weekly inventory cycle counting, and creating a packing list.

The plans made within the supply chain management process are as follows.

Demand Planning: The process of forecasting demand to ensure that products can be delivered reliably and promptly. Effective demand planning can increase the efficiency of revenue forecasts, align stock levels by peaks and drops in demand, and increase margin ability for a specific product or channel.

Product Planning: It is a structured approach to planning, selling, and buying goods to maximize return on funds while making goods available at places, times, quantities, and prices as the market demands.

Procurement Planning: Discovers how best to meet the requirements created from the demand plan. The goal is to balance demand and supply in a way that meets the service and financial objectives of the business.

Production Planning: It is the planning type dealing with production and production modules and creates the resource materials, allocation of workers, and production capacity.

Stock Planning: Determines the optimum timing and quantity to align stock by production and sales needs.

Capacity Planning: Determines the production equipment and personnel required to satisfy product demand.

Sales and Operations Planning: A monthly integrated business management process that empowers leaders to focus on key supply chain factors including sales, marketing, production, demand management, stock management, and new product launch. Competitive advantage increases when you have effective supply chain planning. This advantage helps to minimize the risks inherent in purchasing primal matter and selling your final products or services.

3.2.1. Reducing Costs

This cost reduction is achieved through planning the following.

a) Optimizations in the stock system

b) Optimization of storage space for final products by eliminating damage or degradation of resources
c) Increasing the system's ability to respond to customer requirements
d) Strengthening relationships with both vendors and distributors
e) Optimizations in the transportation
f) Elimination of Delays

A well-planned and executed communication, you can reduce or eliminate stock-outs or delays in supply chain processes. This protects the company from being stock-out and stopping the production line. By becoming more aware of everyone's role in the business and what others are doing, you can reduce problems such as late shipments, logistical errors, and production line delays.

3.2.2 Transportation in The Supply Chain

Among all the processes in the supply chain, few can impact the organization as much as the transportation activity. Transportation methods ensure that the deliveries to and from the enterprise are conducted smoothly and arrive at the designated destinations on time. Because of the importance of transportation to the success of your business, it is vital to incorporate this factor into your supply chain management strategy. Transportation is recognized as one of the three main components of supply chain management. In a supply chain, transport refers to the movement of products from one place to another. This starts at the beginning of the supply chain with the arrival of materials at the warehouse and continues in the customer order with the customer's order to the end-user. In terms of the importance of transportation, warehouse managers should particularly examine transportation within their supply chain. Ultimately, this accounts for up to 60% of total operational costs, a significant portion of an enterprise's supply chain costs, and optimizing transportation is the most effective way to achieve lower overall costs. Transportation is the key logistics function of supply chains from suppliers to customers or stores. It involves product, service transition time, and cost movement, three of the five traditional core issues of effective supply chains. Furthermore, it affects two other issues related to information movement and integration within and between suppliers, customers, and carriers. A transportation strategy that will be effective in supply chain management is to match the movement of products to the corporate supply chain. In other words, it is a way of responding to the dynamics of the business, its customers, suppliers, and operation. The main considerations for transportation in the supply chain are as follows.

Transport Activity Segment: Not all transport destinations have the same priority. Products, suppliers, customers, time of year, and other factors can affect the importance and urgency of transport movements. Strategy cannot be one-dimensional. It should be divided into sections to reflect urgency. These modal changes may create the need for alternative carriers from time to time.

Customer Requirements: The supply chain includes the continuous and efficient movement of products from vendors to manufacturers, to customers. Therefore, the transportation program should reflect and meet customer needs. The time and service aspects of transportation are vital.

Time of Transport: Customers demand that their orders be delivered in full, on the date they need, by the carrier of their choice, by the appropriate transport packaging method. Having a transportation program that can do this ensures customer contentedness and gives the business a competitive advantage.

As a result, shipping is an essential transportation function and critical to supply chain performance. To satisfy the strong requirements of the supply chain, the transportation strategy must be dynamic and sensitive to both service and cost demands. Developments in the globalization process have had a notable impact on the demand for transportation services. This has led to the emergence of a new generation of shipping companies with overly complex systems, and chains, mainly for transporting products with different components. New companies tend to take part in the elements of the entire transport system, that is, to become multimodal companies complemented by state-of-the-art information systems. In order to respond to the increasing needs of the International Transport Federation, transportation companies must be able to:

a) cope with increasing international trade competition,
b) provide service with less unit cost,
c) provide flexible, reliable, fast, and timely door-to-door supply systems,
d) create global and regional distribution networks for passengers and their products,
e) integrate with the new high-speed e-commerce technology.

The impact of global production has also led to the intensification of the transport industry. In other words, the consolidation of transportation companies increases. This, in turn, has led to a greater interdependence between the world economic environment and transportation. Even at the 40th Congress of the International Transport Federation in 2002, "...the globalization of the economy, the technical and organizational capacity of transport, and the modern services of the global economic system, rail operators, road transportation companies, container companies, airlines, and other service providers, transport cannot function without it" especially highlighted. Accordingly, in its global environment, the active trends that reinforce the strategic significance of transport service are:

a) globalization and expansion of flexible production networks,
b) increase in work speed,
c) increasing pressures for operational excellence,
d) development of e-commerce,
e) improved customer service,
f) increase in shipping costs.

With the specialization of production units resulting from the emergence of flexible networks, transportation systems have become more essential, but the expenditures in this area have also increased. Some of the factors that most contribute to increased transport expenditures in the supply chain are as follows.

a) Increasing trend towards the creation of more flexible logistics networks
b) Minimizing the stocks in the chain and thus reducing the working capital
c) Increasing demand for “just in time” services
d) Increased requirements to increase the profitability of transportation services over long distances
e) Increase in brent petrol prices and shipping costs

Transport is one of the parts of the logistics chain where it is most difficult to adapt to the needs of suppliers and customers. In cases where the transportation service is insufficient, delays or product losses are experienced, inconveniences and responsibilities will be directed to the supplier company.

One of the most consolidated trends in recent years is the specialization of production units. Because of this, businesses have focused on the core activity of their performance and tended to make contracts with other businesses related to services. In this context, they preferred subcontracting transportation services. Because they realized that logistics costs are one of the key components in distribution. Trucks, trains, ships, or planes are still required to transport goods and are not currently capable of transporting much faster. In this respect, the reduction in delivery time can be possible with the multi-faceted management of people who work at every link in the chain and the know-how to deal with problems when they arise and establish networks and systems in agreement with their carriers (Logistics Management and Distribution Report, 2000). In this matter, transportation management is a critical issue and is seen as a key element to articulate the supply chain correctly. For a business, the ability to consistently deliver goods on time, at the right price, and with the right quality positively influences the customer’s view of the service. Because of this, transportation should be a quality service for both parts of the process as regards safety, regularity, on-time delivery, and costs. In this respect, neither enterprises nor carriers will be able to solve the problems unilaterally. Coordination of producers and buyers in the chain is also required. Hence, it has become a necessity to be considered a member of the supply chain family in carrier companies. From this point of view, it seems essential to make stable agreements between transport service providers and users to create an overall solution to the problems and a reduction in operating costs. This cost reduction will be reflected in better quality services, adequate rates, and better product prices for consumers (Gunasekaran et al., 2001).

Procurement is one of the main functions of an organization. It is the process of obtaining cost-effective final products or services from preferred suppliers. Procurement procedures and processes differ between organizations. Among other factors, lead times, profit margins, and product quality are significant matters in the supply chain cycle. Procurement begins by reaching the pertinent suppliers and accepting the terms to obtain the lowest possible cost for the business. When a business needs a particular product or service, it initiates the procurement process by receiving requests for proposals through direct interviews or single tenders (Bortolini et al., 2016). A typical procurement process includes:

a) Determining the needs of products and services,
b) Finding the supplier,
c) Requesting an offer,
d) Negotiation with suppliers,
e) Determining the terms of agreement with suppliers,
f) Arranging and receiving products and services,
g) Realization of quality assurance,
h) Researching existing and new markets and products,
i) Evaluating supplier performance,
j) Resolving supplier issues and performance,

k) Maintaining supplier relations,
l) Analyzing results and margins.

Procurement management can be successful when a business effectively identifies suppliers, provides resources, maintains service levels, and establishes strong supplier relationships to achieve the best possible cost price and profit margins for the organization to achieve its strategic goals and objectives. Supplier relationships play a crucial role in an organization's success, and a well-structured procurement management process allows to ensure service levels and expectations are met (Bryan, 1999). Distribution refers to the delivery of final products to the purchasing centers such as shopping centers, grocery stores, and retail stores. Some manufacturers sell their goods directly to authorized resellers. This is advantageous if retailers' workplaces are right near manufacturers' locations.

3.2.3 Costs in The Supply Chain

In today's globalizing economy, most supply chains span multi-regional networks of manufacturers, suppliers, retailers, and distributors spanning the globe. In this environment, it is critical to make smart decisions over up to ten years about where and when to invest in new facilities (such as warehouses and factories) and resources (such as equipment and employees). Many supply chains launch too much money in the wrong locations at the wrong times or fail to invest in the right locations at the right times, adversely affecting their financial holdings. Managing investment costs and making sound strategic investment decisions are essential. Consequently, the following are the matters businesses must-have (Colicchia et al., 2016).

a) End-to-end information covering the entire customer, supplier, manufacturer, distributor, and retailer networks of supply chains
b) Ability to make accurate, data-based demand forecasts for five to ten years,
c) Making a clear market strategy and growth plans

d) Gaining the ability to accurately calculate current and potential funds across the supply chain and explore possible scenarios regardless of their diversity

e) These points are vital to stay in the market and thrive in today’s global economic environment.

3.2.4 Transportation Costs

Transportation costs are the first key factor in overall supply chain costs. Commonly, the root cause of higher shipping costs is inefficient supply chain network planning, routing, and resource deployment for both final products and raw materials and components. In order to minimize shipping costs and times, the business must be able to make the most appropriate possible decisions on the following subject matters. The design of a supply chain network to make sure that manufacturers, and the location of suppliers, customers, and distributors is optimal so that the capacity is used. For instance, by adjusting the load size or by reaching an agreement with third-party logistics businesses when want to eliminate risks of shipment (Ghanbari and Bashiri, 2019). To determine the optimum transportation routes and modes (ship, plane, truck, etc.) used for orders, considering capacity, restrictions, and product-specific requirements. To make the most appropriate selection of manufacturers, suppliers, and distributors working with. Many supply chains see their shipment costs as excessive because they do not consider all the aforementioned aspects, cannot make scenario analyses and make optimal decisions to evaluate different options in terms of shipment route, mode, and partner businesses (Sanchez and Garcia, 2002).

At this point, we need to plan a route to minimize transportation costs. The advantage of this route planning and supplier selection will appear as unit costs and increased competition.

3.3 Company Presentation and Company Problem

Nimo is an active and developing company that has been in the Ukrainian market since 1942. In the Food and Ready Meal Industry, 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, and chains of Ukrainian stores selling its own products. It has a warehouse to store the products it produces in Ukraine, processing in the 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. Therefore, it has started to search for new suppliers and markets. It receives its products and supplies 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 by using maritime shipping.

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. Based on the information they have given us, there is no problem regarding the possible suppliers and their countries as regards quality and shelf-life. For that 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 maritime transportation. A study will be made for 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 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 2 stages as follows.

a) Testing possible supplier routes between containers loaded with raw materials and determining their costs (Raw material)
b) Determining the cost of containers loaded with final products

3.4 Notation

The linear shipping network represented by the graph is represented by $G = (N, A)$ in the type of service. The symbols i and j represent service points in the service network. Letter K to specify the commodity, the declaration D_k is used to symbolize the commodities destination. The expression O_k point out when the network originated the product.

In the settings, C^s_{ij} is represented in service type s and service map as the cost of sending an empty container unit sent from node i to node j. C^k_{ij} is expressed in service type s and service network G as the cost of sending a unit of commodity sent from node i to node j. At a service point, the commodity demand is symbolized by d_k. The capacity of a vessel serving from node i to node j is symbolized by u_{ij}. M represents a number that is non-negative and sufficiently large. The number of nodes in graph G is indicated by N.

In decision variables, Y^s_{ij} represents the flow of empty or loaded containers. The amount of artificial flow indicated for a unit of a commodity is symbolized by ξ_k. x^k_{ij} is the variable linked to the constraints of a unit of product that is sent from node *i* to node *j*.

In clusters, the letter *A* represents the networks in graph *G* and the letter *N* represents the nodes of service on graph *G*. The destination of the product symbolized by N^d and N^o represents the node of service where is the product origin. The letter *K* represents the index of products sent to the service network. *S* represents the group of empty and foldable containers (1, 2, 3, or 4). We have provided this notation in a table to facilitate the presence of notation marks.

Table 3.4.1 Notations

Parameters	
c^s_{ij}	The cost of sending an empty container of type *s* from the service point *i* to service point *j (i, j)*
c^k_{ij}	The cost of sending a unit of product *k* over from the service point *i* to service point *j (i, j)*
d^k	The demand quantity for commodity *k*
u_{ij}	The vessel capacity over the service network from service point i to service point *j (i, j)*
M	A sufficiently large non-negative number
N	Number of nodes in-service network
Decision Variables	

Y^{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}	The 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 and s=4 containers) (Only empty containers)
Miscellaneous	
i	A node of the service network in Graph *G*
j	A node of the 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

3.4.1 Assumptions

Our assumptions are as follows.

A1: Service routes of the liner shipping company known a priori

A2: A weekly demand of cargo is assumed where the origin and destination of cargos of customers are given and deterministic.

A3: Each voyage leg is associated with a known vessel capacity of u_{ij} for all service networks $(i, j) \in A$.

A4: Unlimited number of transshipment operations can be made to deliver a cargo.

A5: Starting port of call of each service route is known beforehand, and all vessels are readily available at the beginning of the planning period.

A6: Empty containers can be folded as a single container containing 1, 2, 3, or 4 empty containers.

In Assumption 1, liner shipping companies identify their service network and service frequencies. In this study, Nimo collects service network and determine their suppliers. In Assumption 2, weekly cargo demand and origin and destination points of cargoes are determined in advance. Service is provided on a weekly basis. This information is deterministic. In Assumption 3, it is emphasized that all vessels serving the service network have a certain carrying capacity (u_{ij}). This user cannot defer more than the load capacity, cannot fulfill demand, and cannot provide service. Amounts remaining above this capacity will either correspond to insufficient demand or another vessel with a capacity of u_{ij}. In Assumption 4, it is assumed that unlimited transactions can be made for each cargo. The operations that can be performed for containerized cargo are transport operations, port operations, and transfers. This assumption is based on the possibility of making unlimited transfers. In accordance with this assumption, it is considered that unlimited cargoes will be brought to the cargo.

Liner shipping companies determine and advertise service networks before serving. For this reason, each service route, the ships to be used in the service, and the capacity of those ships are predetermined. On this basis, it is assumed that the vessels that will provide service on the routes are predetermined and that the fleet is fully available in Assumption 5. In Assumption 6, it is shown that the containers can be folded and transported in groups. Collapsible empty containers can be transported in a single container by placing them in 1, 2, 3, or 4. These containers occupy one container volume in ship capacity *(u_{ij})*.

3.5 Mathematical Model

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

LECP:

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

s.t

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

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

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

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

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

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

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

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

The objective function aims to minimize the cost of liner shipping. C^k_{ij} refers to the cost of sending product from node *i* to node *j* of service type *s*. In the first term, the stream value and stream cost are written to the total symbol and used to find the total shipping cost. In the second term, the expression c^s_{ij} indicates the cost of sending an empty container from node *i* to node j of service type *s*. S^s_{ij} indicates the number of empty container flows. The reason these two terms are multiplied and placed in the total symbol is that all empty container shipping costs are computed. *M* is indicated by a sufficiently large, non-negative number. Considering that the formulation is minimization, it was demonstrated that the value of artificial flows quantity (ξk) should be the smallest for a unit product.

In Constraint number 2, in the type of service s and diagram *G* total variable values from *i* to *j* (x^k_{ij}), subtracting total values from *j* to *i* (x^k_{ji}) and adding the amount of artificial flow for the commodity *k* (ξ^k) is equal to the demand for the product (d^k), if the point of origin of the product is *i*. We will understand that the quantity of artificial flow for commodity *k* (ξk) and the demand for commodity *k* are equal.

In Constraint number 3, parallel to Constraints 2 and 4, in-service type s and diagram G of the variable values from *j* to *i* (x^k_{ji}), the total subtraction of the values from j(x^k_{ij}) and the subtraction of the quantity of artificial flow for the commodity *k* (ξ^k) is equal to the minus demand of the product $(-d^k)$, if destination point of the product is *i*.

In Constraint number 4, the dual variable total that is sent from node *i* to node *j* and the dual variable total that is sent from node *j* to node *i* are equal. Because the liner shipping network is circularly planned. Therefore, the incoming and outgoing flows are equal.

In Constraint number 5, the sum of the total dual variable associated with the constraints that are sent from service point *i* to service point *j* and the total flow of empty containers must be less than the vessel capacity (u_{ij}). Because the flow of goods and the flow of empty containers used the ship's capacity. The capacity of the ship is fixed. More than the capacity of the container cannot be moved.

In Constraint number 6, the number of empty containers returning from service point *j* to service point *i* (S^s_{ji}) the subtraction of the number of empty containers sending from service point *i* to service point *j* (S^s_{ij}), and the result found multiplied by several groups of containers *(s)*. Eventually, we will find the number of empty containers at service point i. In the service type s and G diagram of the dual variable values from i to j (x^k_{ij}), the subtraction of the values from j to i (x^k_{ji}) is equal to the total quantities of the flows of the containers. The subtraction of result 1 and result 2 must be greater than zero. Because empty containers on the route must return to the starting point to meet the minimum demand. The other constraints show that the flow value cannot be negative.

3.6 Application

3.6.1 Possible Raw Material Supply Routes

There is no need for cold chain applications for raw materials. So, the containers we use can be used as laden and foldable containers. The model was used in the same form for supplier selection. The container used for raw material is shown in the picture below.

Figure 3.6.1.1 Foldable Container

1st possible 3 supplier countries are as follows.

a) Spain
b) Tunisia

c) Belgium

According to the information given, the service network provided by LS companies for these four countries was presented below.

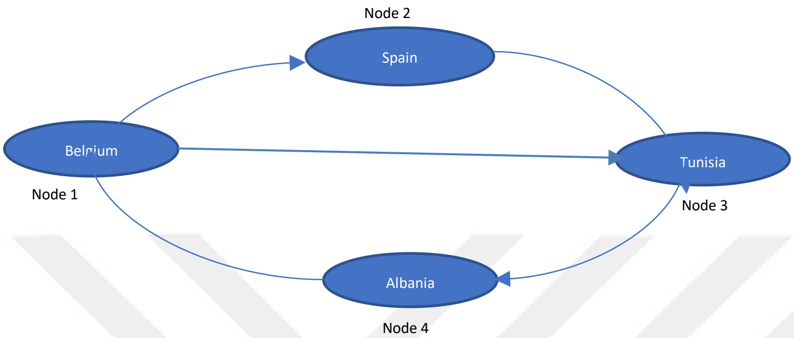

Figure 3.5.1.2 Service Map for 1st Scenario

The information required for the model is shown in the tables below.

Table 3.6.1.1 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 3.6.1.2 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 3.6.1.3 Countries and Container Demands for 1st Scenario

Country	Container Demands
Belgium	200

Spain	200
Tunisia	200
Albania	600

Vessel capacities for each service point are equal and 800 containers. Using GAMS for LECP. The objective function minimization that GAMS found is as follows. Vessel capacities for each service point are equal and 800 containers. The GAMS codes used are given in the appendices section.

```
Version identifier: 22.1.0.0 | 2022-03-09 | 1a383f8ce
CPXPARAM_Advance                                        0
CPXPARAM_Simplex_Display                                2
CPXPARAM_Threads                                        1
CPXPARAM_MIP_Display                                    4
CPXPARAM_MIP_Pool_Capacity                              0
CPXPARAM_TimeLimit                                      600
CPXPARAM_MIP_Tolerances_AbsMIPGap                       0
CPXPARAM_MIP_Tolerances_MIPGap                          0
Tried aggregator 1 time.
LP Presolve eliminated 0 rows and 22 columns.
Reduced LP has 21 rows, 66 columns, and 239 nonzeros.
Presolve time = 0.00 sec. (0.09 ticks)

Iteration      Dual Objective            In Variable           Out Variable
     1           2400.000000                x(1,4,1)      kisit1(1,1) artif
     2           6000.000000                x(2,1,2)      kisit1(2,2) artif
     3           8200.000000                x(3,1,3)      kisit1(3,3) artif
     4          10600.000000                x(1,4,2)      kisit2(2,4) artif
     5          11000.000000                x(3,4,3)      kisit2(3,4) artif
     6          11400.000000                x(3,2,3)        kisit5(2) slack
     7          11800.000000                y(3,2,4)        kisit5(1) slack
     8          12700.000000                y(4,2,4)        kisit5(3) slack
     9          13100.000000                y(4,3,4)               y(3,2,4)
    10          13500.000000                x(3,4,2)      kisit3(3,1) artif
    11          13950.000000                y(3,1,4)      kisit3(2,1) artif

--- LP status (1): optimal.
--- Cplex Time: 0.00sec (det. 0.13 ticks)


Optimal solution found
Objective:          13950.000000
```

Figure 3.6.1.3 GAMS Solution for 1st scenario

Using the given information above, the optimal solution of the objective function was found to be 13,950.

2nd possible 3 supplier countries are as follows.

a) Portugal
b) Morocco
c) Italy

According to the information given, the service network provided by LS companies for these four countries was demonstrated below.

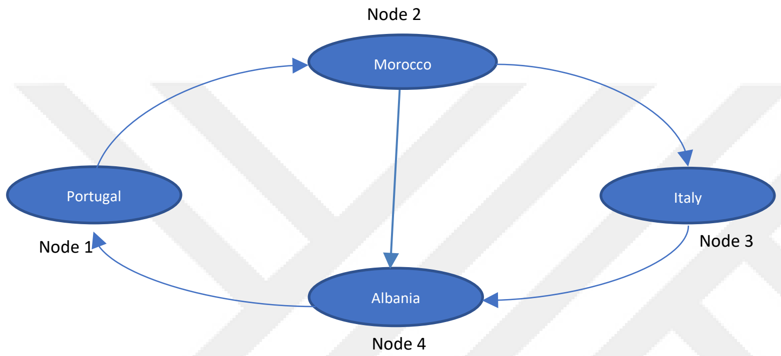

Figure 3.6.1.4 Service Map for 2nd Scenario

The information required for the model is shown in the tables below.

Table 3.6.1.4 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
Albania	Portugal	33

Table 3.6.1.5 Commodities Origins and Destinations 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 3.6.1.6 Countries and Container Demands for 2nd Scenario

Country	Container Demands
Portugal	200
Morocco	200
Italy	200
Albania	600

```
Version identifier: 22.1.0.0 | 2022-03-09 | 1a383f8ce
CPXPARAM_Advance                                 0
CPXPARAM_Simplex_Display                         2
CPXPARAM_Threads                                 1
CPXPARAM_MIP_Display                             4
CPXPARAM_MIP_Pool_Capacity                       0
CPXPARAM_TimeLimit                               600
CPXPARAM_MIP_Tolerances_AbsMIPGap                0
CPXPARAM_MIP_Tolerances_MIPGap                   0
Tried aggregator 1 time.
LP Presolve eliminated 0 rows and 22 columns.
Reduced LP has 21 rows, 66 columns, and 239 nonzeros.
Presolve time = 0.00 sec. (0.09 ticks)

Iteration      Dual Objective            In Variable           Out Variable
     1            1400.000000               x(1,2,1)      kisit1(1,1) artif
     2            5000.000000               x(2,1,2)      kisit1(2,2) artif
     3            6000.000000               x(3,4,3)      kisit1(3,3) artif
     4            6800.000000               x(1,4,1)      kisit2(1,4) artif
     5            7800.000000               x(3,4,2)      kisit2(2,4) artif
     6            9200.000000               y(4,3,4)        kisit5(3) slack
     7            9700.000000               x(2,3,2)      kisit3(2,1) artif
     8           10500.000000               y(2,1,3)        kisit5(1) slack
     9           11300.000000               x(3,1,3)        kisit5(2) slack
    10           11600.000000               y(3,1,4)      kisit3(3,1) artif
    11           11950.000000               y(4,2,4)               y(2,1,3)

--- LP status (1): optimal.
--- Cplex Time: 0.00sec (det. 0.13 ticks)


Optimal solution found
Objective:          11950.000000
```

Figure 3.6.1.5 GAMS Solution for 2nd scenario

Using the given information above, the optimal solution of the objective function is 11,950.

3rd possible 3 supplier countries are as follows.

a) Denmark
b) Portugal
c) Tunisia

According to the information given, the service network provided by LS companies for these four countries is shown below.

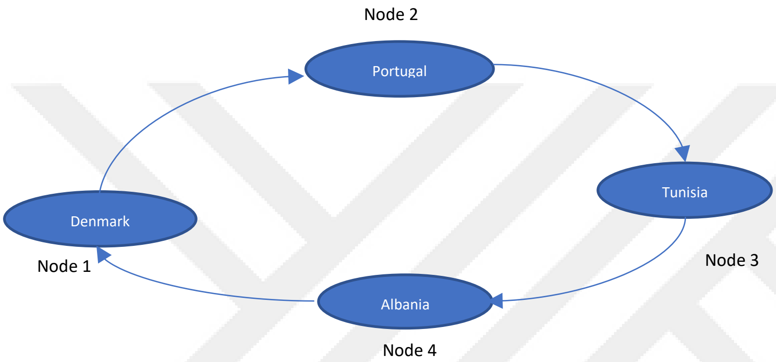

Figure 3.6.1.6 Service Map for 3rd Scenario

The information required for the model is shown in the tables below.

Table 3.5.1.7 Arcs and Cost Coefficient 3rd Scenario

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

Table 3.6.1.8 Commodities Origins and Destinations 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 3.6.1.9 Countries and Container Demands 3rd Scenario

Country	Container Demands
Denmark	200
Portugal	200
Tunisia	200
Albania	600

```
Version identifier: 22.1.0.0 | 2022-03-09 | 1a383f8ce
CPXPARAM_Advance                                  0
CPXPARAM_Simplex_Display                          2
CPXPARAM_Threads                                  1
CPXPARAM_MIP_Display                              4
CPXPARAM_MIP_Pool_Capacity                        0
CPXPARAM_TimeLimit                                600
CPXPARAM_MIP_Tolerances_AbsMIPGap                 0
CPXPARAM_MIP_Tolerances_MIPGap                    0
Tried aggregator 1 time.
LP Presolve eliminated 0 rows and 25 columns.
Reduced LP has 20 rows, 63 columns, and 226 nonzeros.
Presolve time = 0.00 sec. (0.09 ticks)

Iteration      Dual Objective            In Variable           Out Variable
     1            3000.000000               x(1,4,1)      kisit1(1,1) artif
     2            7050.000000               x(2,1,2)      kisit1(2,2) artif
     3            9750.000000               x(1,4,2)      kisit2(2,4) artif
     4           11950.000000               x(3,1,3)      kisit1(3,3) artif
     5           12350.000000               x(3,4,3)      kisit2(3,4) artif
     6           12800.000000               x(3,2,3)        kisit5(2) slack
     7           13275.000000               y(3,2,4)        kisit5(1) slack
     8           14287.500000               y(4,2,4)        kisit5(3) slack
     9           14687.500000               y(4,3,4)               y(3,2,4)
    10           15187.500000               x(3,4,2)      kisit3(3,1) artif
    11           15750.000000               y(3,1,4)      kisit3(2,1) artif

--- LP status (1): optimal.
--- Cplex Time: 0.00sec (det. 0.13 ticks)


Optimal solution found
Objective:          15750.000000
```

Figure 3.6.1.7 GAMS Solution for 3rd Scenario

Using the given information above, the optimal solution for the objective function is 15,750.

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

3.6.2 Possible Market Route

The newly opened factory needs market areas to realize product sales. Normally, it produces in Ukraine and imports its products. However, it wants to increase its competitiveness with low costs in the market. Necessary studies have been conducted to reduce costs in the supply chain process and possible scenarios have been determined as the supplier route above. The cost of the products could reduce to import its products has become achievable only by transporting the products. Liner Shipping stands out with its much lower transportation costs. The use of a cold chain is required for the final product. Therefore, the foldability sign (s=1) will be taken 1 from our mathematical model. The container used for the cold chain is shown in the picture below.

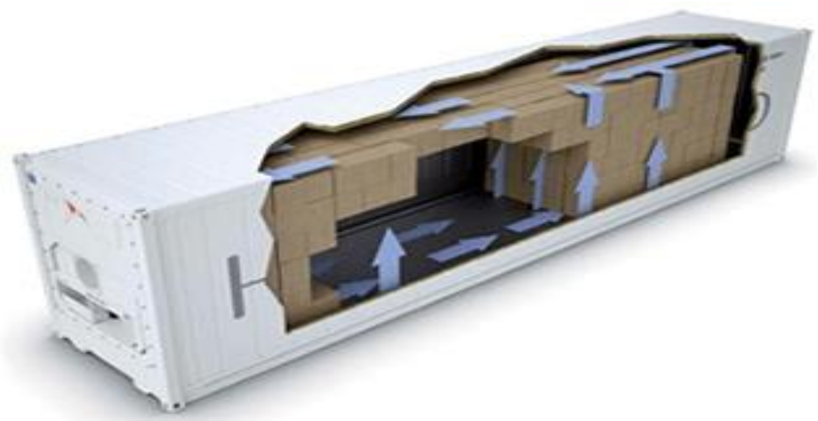

Figure 3.6.2.1 Reefer Container Air Flows

Figure 3.6.2.2 Reefer Container

Possible market countries are as follows.

a) Spain
b) Greece
c) Ireland
d) The UK

Since the information that should be given on the packaging of the product changes in countries' regulations, final products are not the same for all countries. Accordingly, our commodity (*k*) figure will be taken as 4 and the destination of each product will be given as information in the tables. Based on the information given, the service network provided by LS companies for these four countries is shown below.

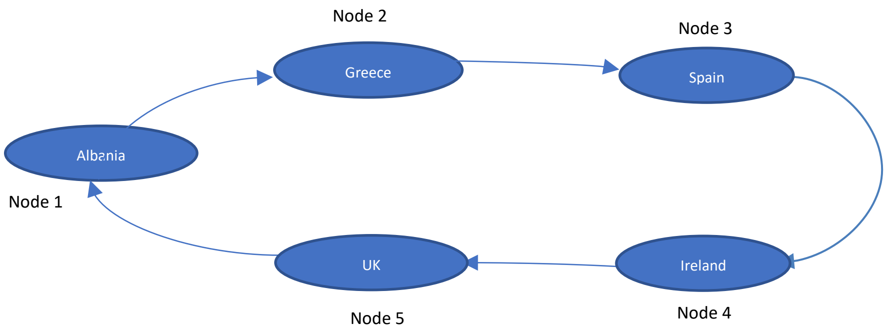

Figure 3.6.2.3 Service Map for Market Route

The information required for the model is shown in the tables below.

Table 3.6.2.1 Arcs and Cost Coefficient for Market

Origin (node *i*)	Destination (node *j*)	Cost Coefficient
Albania	Greece	5
Greece	Spain	24
Spain	Ireland	17
Ireland	UK	4
UK	Greece	55

Table 3.6.2.2 Commodities Origins and Destinations for Market

Commodity	Origin (node *i*)	Destination (node *j*)
Final Product 1	Albania	Greece
Final Product 2	Albania	Spain
Final Product 3	Albania	Ireland
Final Product 4	Albania	UK

Table 3.6.2.3 Countries and Container Demands for Market

Country	Container Demands
Greece	250
Spain	250
Ireland	250
UK	250
Albania	1000

Vessel capacities for each service point are equal and 800 containers. Using GAMS for LECP without foldable coefficient (s=1). The objective function minimization that GAMS found is as follows. The GAMS codes used for the possible market scenarios are given in the appendices section.

```
Version identifier: 22.1.0.0 | 2022-03-09 | 1a383f8ce
CPXPARAM_Advance                                        0
CPXPARAM_Threads                                        1
CPXPARAM_MIP_Display                                    4
CPXPARAM_MIP_Pool_Capacity                              0
CPXPARAM_TimeLimit                                      600
CPXPARAM_MIP_Tolerances_AbsMIPGap                       0
CPXPARAM_MIP_Tolerances_MIPGap                          0
Tried aggregator 1 time.
LP Presolve eliminated 0 rows and 5 columns.
Aggregator did 1 substitutions.
Reduced LP has 30 rows, 99 columns, and 378 nonzeros.
Presolve time = 0.00 sec. (0.14 ticks)
Initializing dual steep norms . . .

Iteration log . . .
Iteration:     1   Dual objective     =          2750.000000

--- LP status (1): optimal.
--- Cplex Time: 0.00sec (det. 0.21 ticks)


Optimal solution found
Objective:        26950.000000
```

Figure 3.6.2.3 GAMS Solution for Market Route

Using the above information, the optimal solution for the objective function is 26,950.

4. RESULTS AND DISCUSSION

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 have computed the cost coefficient as 13,950 using GAMS for LECP.

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

a) Portugal
b) Morocco
c) Italy

We have computed the cost coefficient as 11,950 using GAMS for LECP.

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

a) Denmark
b) Portugal
c) Tunisia

We have computed the cost coefficient as 15,750 using GAMS for LECP.

The supplier countries we chose in the light of the information above are Portugal, Morocco, and 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 coefficients.

When the choices and transportation we described above are used, the cost coefficient will be 38,900 for the total cost. The company informed that if land transportation is used, the cost coefficient will be 50,000. In this direction, we have achieved approximately 22.2% cost savings with our work.

5. CONCLUSION

The concept of the supply chain is as old as economics. From sourcing to production and delivery, the different actors in a particular market form the links in a chain, namely customers and suppliers. However, the intensification of competition and the phenomenon of globalization has led companies to realize that the players in their supply chains share a single goal. The final and main goal is to satisfy the customer. Hence, the organization and performance of this supply chain are of vital and increasing strategic importance for companies. For the food industry, where there is an increase in production rate to meet high demand, this is a recurring theme in the current economy that illustrates the strategic role mentioned above. In fact, this problem exists in all sectors of the economy, both in industry and services. In order to improve the results of companies, researchers and managers are exploring different ways of optimizing supply chain management on concepts such as collaboration, integration, and knowledge exchange. The difficulty of minimizing costs in the supply chain this problem lies in the complexity of the supply chain management: In addition to the number of links, results must be taken into account, and in particular the number of parameters a company can work on to achieve its performance. Goals that turned out to be endless.

The supply chain is the general expression of the system of manufacturing and sending a commodity or service from the very beginning of the procurement of primal matters to the final delivery of the commodity or service to the end consumers. The supply chain is a set of processes that encompasses all aspects of the manufacturing process, contenting the activities involved at each level, the information transmitted, the natural resources converted into useful products, human resources, and other components that go into the final 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 to reduce the cost for exporting countries. Increasing fuel costs in the global have put excessive pressure on the cold chain. Consequently, maritime shipping 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.

Globally increasing fuel prices 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 quantity of fuel used harms our planet constantly. Besides the cost optimization, this study was also conducted 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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APPENDICES

APPENDIX A

Used GAMS code is as follows

```
Sets
i a node of the service network /1,2,3,4/
alias(i,j) ;
Sets
k a commodity /1,2,3/
Ok(k,i) origin node of commodity k /1.1,2.2,3.3/
Dk(k,i) destination node of commodity k /1.4,2.4,3.4/
A(i,j) set of arcs in graph /1.2,2.3,3.4,2.4/
s type of the container /1,2,3,4/ (if using non-foldable container write 1)
Mapofik(k,i) / #k.#i /
submap1(k,i) birinci adim

Nfokdk(k,i) finalform ;
submap1(k,i) = Mapofik(k,i) - Ok(k,i) ;
Nfokdk(k,i)= submap1(k,i) - Dk(k,i) ;
Parameters
cs(i,j,s)/
$include “C:\Users\ahmetk\Desktop\GAMS\sendingcost.txt;”
/
ck(i,j,k)/
$include “C:\Users\ahmetk\Desktop\GAMS\sendingcostk.txt;”
/
d(k)/
$include “C:\Users\ahmetk\Desktop\GAMS\demandk.txt;”
/
u(i,j)/
$include “C:\Users\ahmetk\Desktop\GAMS\vescapacity.txt;”
```

```
/
M /999999999/

Positive variables
y(i,j,s) amount of empty container flow
err(k) artifical flow
x(i,j,k) dual var associated;

Variable
z obj value ;

Equations
objectivef
kisit1(k,i)
kisit2(k,i)
kisit3(k,i)
kisit4(i,j)
kisit5(i) ;

objectivef..        z       =e=       sum((i,j,k),ck(i,j,k)*x(i,j,k))       +
sum((i,j,s),cs(i,j,s)*y(i,j,s))+sum(k,M*err(k)) ;
kisit1(Ok(k,i)).. sum(j,x(i,j,k)) - sum(j,x(j,i,k)) + err(k) =e= d(k) ;
kisit2(Dk(k,i)).. sum(j,x(i,j,k)) - sum(j,x(j,i,k)) - err(k) =e= -d(k) ;
kisit3(Nfokdk(k,i)).. sum(j,x(i,j,k)) - sum(j,x(j,i,k)) =e= 0 ;
kisit4(A(i,j)).. sum(k,x(i,j,k))+sum(s,y(i,j,s)) =l= u(i,j) ;
kisit5(i).. sum((j,s),ord(s)*(y(j,i,s)-y(i,j,s)))-sum((k,j),x(i,j,k)-x(j,i,k)) =g= 0 ;
Model lecp  /all/
mods /all/;
mods.optFile=1;
Option
```

```
optcr=0.00
optca=0.00
Option
reslim = 600
Solve lecp using LP minimizing z ;
display x.l, y.l, err.l ;
```

BIOGRAPHICAL SKETCH

Ahmet Karakaya graduated from Alparslan Anatolian High School located in Ankara, Turkey. He later graduated from the Galatasaray University, Department of Industrial Engineering.