(REFEREED RESEARCH)

SUPPLY CHAIN OPTIMIZATION AND DISTRIBUTION NETWORK APPLICATION WITH AHP IN A YARN COMPANY

TEDARİK ZİNCİRİ OPTİMİZASYONU VE İPLİK İŞLETMESİNDE AHP İLE DAĞITIM AĞI UYGULAMASI

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ABSTRACT

In today's global market, entire management of supply chain becomes a key factor for successful business processes. Worldwide organizations realize they're inadequate for success in non-integrated manufacturing/distribution processes&weak realitionships with suppliers/customers. Supply chain management becomes main solution for getting high profits and low costs. A fundamental characteristic of logistics is holistic structure with integrated view of all activities. Logistics is distribution of important components like procurement, warehouse management, inventory management, transportation management. It also deals with integration and other activities to provide time and value to the system or corporation.The problems have been determined by SWOT Analysis in a company.In this study, model of Analytical Hierarchy Process is designed for solution of supplier selection problem; Distribution network problem is modelled with linear programming and solved by using WinQSB software. In this paper, the optimized distribution network from yarn company to warehouse and customers is tried to achieve by developing optimized supply chain model.

Key Words: Supply chain management, SWOT analysis, Analytical Hierarchy Process (AHP), Distribution network, Linear programming, Optimization.

ÖZET

Günümüz küresel pazarında, tedarik zincirinin bütünsel yönetimi başarılı iş süreçlerinin anahtar etkeni haline gelmiştir. Dünya çapındaki organizasyonlar, entegre edilmemiş üretim/dağıtım proseslerinin ve zayıf müşteri/tedarikçi ilişkilerinin başarılarını yetersiz kıldıklarının farkına varmışlardır. Tedarik zinciri yönetimi, karı arttırmanın ve maliyeti düşürmenin temel çözümü haline gelmiştir. Lojistiğin en temel karakteristiği, içerdiği tüm aktiviteleri entegre eden bir bakış sunan, tüme dayalı yapısıdır. Lojistik; tedarik zamanı, stok yönetimi, taşıma yönetimi, depo yönetimi ve tüm önemli bileşenlerin dağıtımı olup tüm bunlar ve diğer aktivitelerin entegrasyonu ile sistem ya da işletmeye zaman ve değer kazandırmakla ilgilenir.İşletmede SWOT analizi ile sorunlar tesbit edilmiştir.Bu çalışmada tedarikçi seçim problemine Analitik Hiyerarşi Prosesi ile çözüm getirilmiş; dağıtım ağları problemi ise doğrusal programlama ile modellenmiş ve WinQSB paket programı ile çözülmüştür. Bu çalışma ile optimize edilmiş tedarik zinciri modeli kurularak iplik işletmesi ile dağıtım yerleri ve müşteriler arasındaki en uygun dağıtım ağı oluşturulmaya çalışılmıştır.

Anahtar Kelimeler: Tedarik zinciri yönetimi, SWOT analizi, Analitik Hiyerarşi Prosesi (AHP), Dağıtım ağları, Doğrusal programlama, Optimizasyon.

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1. INTRODUCTION

Optimization models are used to better understand the functional relations between the business and external world in supply chain management. Demand forecast and other data must be combined to establısh a global optimization model which meets demand and minimum cost of supply chain and which decides which center will produce which product and send to which distribution center.

General introduction is presented in the first part, the concepts of supply chain and supply chain management for the second part, objectives, developments and processes are determined, advantages and disadvantages are evaluated.In third chapter, supply chain optimization are discussed.In the fourth chapter, firstly the problems encountered are revealed by SWOT analysis in a yarn firm operating in Denizli Textile Industry based on these results, solutions are tried to obtain.These solution is brought by AHP for supplier selection problem which is one of the weaknesses of the business, the optimization of distrubutions is solved

by establishing a linear programming model.In conclusion and recommendation part, the results are discussed and suggestions are presented for the future studies.

2. SUPPLY CHAIN

The success of the business model depends on not only the output of goods and services but also inputs affecting quality and price of these outputs.Supply is a wide concept including a number of actions from market research to orders, purchase, loading and unloading.Supply with the sense of purchase must be cared as management activity.Purchase is the final stage of these administrative activities (1).

A supply chain is a set of relationships and connections that enable movement between products, suppliers, manufacturers, wholesalers, distributors, retailers and consumers (2). With the perspective of business processes, supply chain covers many areas like sales process, production, inventory management, procurement, distribution, sales forescast and customer service (3). During this process, according to the orders, raw materials and other components are turned into products and delivered to customers. As seen above, the first link in the supply chain is raw material supply, its last link is product delivery to the customer.In fact, in a succesful supply chain, the first link must be the consumer and the last link must be the product suppliers.Production is located in the middle of them.Because production is made for custumers, so it's very important to provide the back flow of their thoughts towards information. Accordingly, the supply chain for customers includes the elements lile production, distribution, marketing, logictics and after-sales service in order to meet the needs in time (4).

Supply chain management, uses operation research mathematicss, advanced technology and information management to plan and control the factors compenent for producing goods and services that will please the consumers. It uses advanced programs, relational databases and other similar technical tools.Although its technology is complex, it's easy to understand its most important concepts and study (5). The share information and plans with suppliers and customers can increase it's competitiveness and efficiency (6).

The basic philosophy of supply chain management is to minimize the cost of total supply chain in accordance with demand.Supply chain in accordance with demand. Supply chain management dates back the 1960's. Initial emphasis on the physical distribution phase considered as the first stage of supply chain management was made by Bowersox. In addition to the observation of physical distribution idea, Bowersox claims that distribution function provides a competetive advantage outside the company with canal-inside integration (7).

In the 1980's, increased global competition forces worldwide companies to offer reliable products with lower cost but higher quality with more design flexibility. In that period, the second stage of supply chain management is passed (8). This phase is defined as the integration of logistics by Ross (9). Combining firm's strategic decission and logistics-oriented approach, Haulihan develops a strong case considering the the supply chain as a single case (10). Thus, Houlihan for the first person using the term "supply chain" for this system in the literature (11).

After that period, in 1985's, the first pioneer of the supply chain Quick Response (Q.R.) system is developed. QR program is introduced firstly in the textile sector as the first pioneer of the supply chain and then in 1990's; An extension of it in retailing sector, Efficent Consumer Response (ECR) programs are followed (12). After ECR Continuous Replenishment Planning (CRP) is obtained. After the mid-1990's, managers realize that goods and services suppliers has an important effect on the ability to meet customer needs.Managers also understand that producing high quality goods isn't sufficent alone at the same time. The new success method is to convey products to the customers at desired time, place, shape and quantity with cost-effective way.As a result of all these developments, managers recognize that it isn't enough to manage only their own businesses so they realize that all networks must be located including both all upstream business getting input and all downstream businesses conveying products to the customers and presented after-sales service (13). This period is called the stage of the supply chain management in literature (9). In the same period, Metz uses the expression of the integrated supply chain management phase (8). Metz call the next stage as superb Supply Chain Managemen phase.

All of manufacturing enterprises have supply chain management systems. But, many of them are complex, uncontrollable or aren't developed. Similarly, some businesses can't realize full integration, and unified functional system. In case of developed competitive position, it must be examined continuously where the businesses are. Supply chain management sometimes causes time consuming much because of priority activities and therefore the application of supply chain management can't be obtained at the desired level. Concentration on the wrong initiatives leads to unnecessary costs (14).

3. SUPPLY CHAIN OPTIMIZATION

The purpose of supply chain management is to be with low cost and effective for all system. All costs must be minimized like from transportation and distribution costs of raw materials to semi-finished goods, last product stocks. Therefore, the main purpose of supply chain management is not only to reduce the transportation or stock costs, but also to implement system aproach to supply chain management. The third important issue is that supply chain management involves many activities of an enterprise based on the strategic, tactical and operational level, because it deals with integration of suppliers, manufacturers, warehouses and stores (15).

Although every supply chain model has its own pecularities, many of them requires the defination of the problem, the identification of targets and execution of steps in the formulation of the (16). Supply chain constraints are factors based on a number of alternative decisions that businesses can choose. Thus, these factors determine some decision alternatives feasibility. These constraints are capacity, service adoption and demand scope/amount (17). Because of determining the limits of output range, the decision variables generally

contribute an increase in functional performance associated with supply chain. So in general, performance metrics of a supplu chain can be expressed as a function of the decision variables (17). Some of decision variables can be listed as place, location, network structure, the number of facilities and equipment, the number of phase-layer, service frequency, quantity, inventory level, the amount of labor, the scope of foreign-source (18).

4. SUPPLY CHAIN OPTIMIZATION APPLICATION IN A YARN COMPANY

Yarn factory for the study(19) aims to be one of successful business in textile manufacturing, with new investments and 30 000 yarns capacity and advanced technology, tencel, linen, bamboo, PVA (Vinal), special fibers, such as wool and angora blended products, except as core yarn, slub yarns. The aim of this study is to create the best approaches for the difficulties in present study system and provide the improvement of difficulties identified.

In practice, firstly, to see the profile of enterprises relationships between internal and external environment, SWOT analysis (strengths, weaknesses, opportunities, threats) is used, one of the most effective evaluation methods including enterprises, institutional functions, competitiveness, market position, external threats and in the light of identified problems, arrangements are made for the size of case study. Weaknesses resulting from SWOT analysis are handled as a case and it's created the structure of optimized supply chain through suggestions for their improvements.In this context, it's tried to find solutions for the difficulties with AHP, one of multi-criteria decision-making methods and used at all levels of micr and macro scale from all areas of life. Taking into account the relationship between decision variables and total cost, it's created a linear programming model proving the optimization and solved by WİNQSB program.

4.1. Current Situation Analysis and Problem Determination

It's obtained the current situation evaluation with two managers about market quality, competition quality, cost structure and distribution channel structure. Each enterprise has the sides of superior(S) and weaknesses(W) depending on resources and capabilities. Due to the continuous changes in enverimental conditions, business face an opportunity(O) or a threat (T) (20). The results from SWOT analysis are shown in Table 1.

The studies are done about weaknesses emerged after analysis and aimd to identify problems. Due to quality problems of raw material, the loss of customers results from not taking correct product from correct supplier. For solution of this problem, AHP must be implemented, one of the most important cases of the supply chain for the supplier selection. In relation to distribution network, as a result of not creating new manufacturing locations with especially external investments of the enterprise, the biggest possible problem of the enterprise is not to meet logistics in frastructure needs. It seems to reach the desired goal of minumum cost by low-cost production factories in the determination of the most suitable distribution costs. Dealing with this problem, the distribution network is though to solve modelling by linear programming.

4.2. Supplier Selection Problem Solution By Analytic Hierarchy Process

For the best supplier selection during this multi-criteria decision-making process, it's necessary to reach a compromise between conflicting criteria each other and to determine priorities. Supplier selection problem can be seen in two ways: while the first one is that alternative suppliers meet all demands of manufacturers (quantity, quality, delivery time, etc.), the second one is that suppliers have capacity, quality, constrains and no supplier can't fulfill all expectations alone. In the first case, a supplier selected will meet all needs in the other case, there will be an obligation to work with multiple suppliers and to buy each one different amounts of raw material/intermediate product. Decision-makers must choose the supplier that best meet all the company's expectations among the alternatives (21). Fierce market competition occurs in many countries with new developments in many countries, organizations have to meet their customer needs with new products, services and in parallel make collaborations with suppliers(22).

Table 1. SWOT analysis for the enterprise

STRENGTH: Image, Technology, Infrastructure, Wide product range	**WEAKNESSES:** Loss of Customers, Losses in Distribution of the costs incurred in, The length of the decision-making process
OPPORTUNITIES : The structure of develop the new products, New market opportunities, Financial strength as a result of a business combination	**THREATS:** Entry into the market of the importing market**,** Pricing in increasingly competitive environment

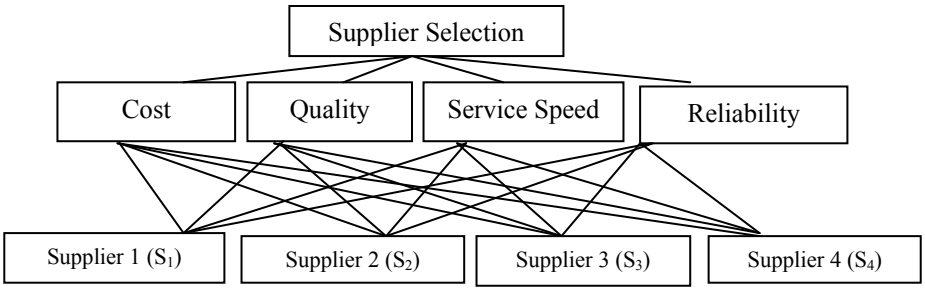

Figure 1. A hierarchical structure for supplier selection problem

Supplier selection is an important problem with many criteria like cost, quality, performance, technology etc. Not only the cost of materials, but also the operating costs, maintenance, development and support costs are factors to be considered in this election. Thus, there is a need of criteria evaluation and priority lines of criteria for a systematic vendor selection process among criteria about efficiency and performance raitings. This process both shorten the selection process and also increase the success in decision-making (23).

The Analytic Hierarchy Process (AHP) developed by Thomas L. Saaty (1980) is one of the widely used multi-criteria decision-making methods. AHP method is based on the operation of managerial decision-making for analyzing the complex decision problems by giving the relative importance values to alternatives and criteria.

AHP method allows decision-makers to model complex problems in a hierarchical structure showing the relationship between the main objective of the problem, criteria, sub-criteria and alternatives. The most important feature of the method of AHP is to insert both objective and subjective ideas of decision-maker into decision-making process. Namely, AHP is a way combined with knowledge, experience, a person's ideas and intuitions logically (24). In addition another important feature of the method of AHP is separation and finding the problems during the creation of a hierarchical structure (25). By using AHP, primarily the hierarchy given in figure 1 have been formed in order to improve the selection of suppliers the criteria specified by decision maker on the basis of the model. Our goal is to select the best supplier on the basis of selected criteria in this study.

The largest and most important supply item is raw material in a yarn company. For this reason, selection criteria and suppliers in our application formed for the viscose fibers of purchasing of raw materials. Our selection criteria which will use in this study were determined as cost, quality, service speed and reliability.

Entity's market share, market image, ideas occured at working with this business at past times, credibility provides a pairwise comparison matrix formation. Firstly a binary comparison matrices was established supplier alternatives which is evaluated for each criterion. This binary comparisons are the result of two expert people on the mutual discussions.

Table 2. Matrix according to the criteria of cost

COST	S_1	S_2	S_3	S_4
S_1	1	3	5	1/3
S_2	1/3	1	3	1/5
S_3	1/5	1/3	1	1/7
S_4	3	5	7	1
Consistency index: 0,04				

Table 3. Matrix according to the criteria of quality

QUALITY	S_1	S_2	S_3	S_4
S_1	1	1/5	3	1
S_2	5	1	5	3
S_3	1/3	1/5	1	1/3
S_4	1	1/3	3	1
Consistency index: 0,04				

A pairwise comparison matrix which established on the basis of supplier firms' 'cost' criteria had been shown in Table 2. The binary comparison matrix established such as in Table 3 on the basis of enterprise's "quality" criteria, supplier of enterprises manufacturing technologies, used by quality systems, quality of packaging. The pairwise comparison matrix established in Table 4 to ensure that raw materials are reported and expected time on the basis of 'service speed' criteria. The pairwise comparison matrix according to 'reliability' criteria shown in Table 5.

Table 4. Matrix according to the criteria of service rate

SERVICE SPEED	S_1	S_2	S_3	S_4
S_1	1	1/3	1/5	1
S_2	3	1	1/3	3
S_3	5	3	1	5
S_4	1	1/3	1/5	1
Consistency index: 0,02				

Table 5. Matrix according to the criteria of reliability

RELIABILITY	S_1	S_2	S_3	S_4
S_1	1	1/5	1/3	3
S_2	5	1	3	7
S_3	3	1/3	1	5
S_4	1/3	1/7	1/5	1
Consistency index: 0,04				

After the creation of pairwise comparison matrices on the basis of criteria which defined, the pairwise comparison matrix established for the four criterion for supplier selection problem. At this stage, the relative importance of criteria for decision-makers were asked to scoring. Pairwise comprasion matrix which rated criteria between themselves are provided in Table 6.

After the creation of pairwise comparison matrices, priority vectors and consistency ratios were calculated for each criteria and pairwise comprasion matrix of four criteria between themselves. On the basis of criteria established for each pairwise comparison matrices among the options and pairwise comparison matrix generated from criteria seen to be consistent. After obtaining the priority vectors, priorities matrix established in Table 7 for target using related to vectors and priority matrix for supplier selection problem created in Table 8.

Table 6. The pairwise comparison matrix for selection criterias

	Cost	Quality	Service Speed	Reliability
Cost	1	1/3	½	5
Quality	3	1	2	4
Service Speed	2	1/2	1	4
Reliability	1/5	1/4	¼	1
Consistency index: 0,02				

Table 7. Priorities matrix for the target

Cost	0,156
Quality	0,462
Service Speed	0,294
Reliability	0,088

Table 8. Priority matrix for the supplier selection problem

	Cost	**Quality**	**Service Speed**	**Reliability**
S_1	0,262	0,168	0,095	0,118
S_2	0,118	0,570	0,249	0,565
S_3	0,055	0,075	0,560	0,262
S_4	0,565	0,187	0,095	0,055

The most important criterion for decision-making was found a criterion of quality based on the priorities matrix for the target. This criteria is followed respectively service speed, cost and reliability. Businesses that have a high priority in the priority matrix for supplier selection problem determined as S_4 business on the basis of cost, S_2 business on the basis of quality, S_3 business on the basis of service speed and again S_2 business on the basis of reliability. In order to determine business priorities, priority matrix for supplier selection problem in Table 7 and priorities matrix for target in Table 8 multiplied and the final table provided in Table 9.

Table 9. Business priorities obtained by AHP

S_1	0,157
S_2	0,405
S_3	0,231
S_4	0,208

AHP for supplier selection and the best supplier of the application according to the criteria specified is determined as 0.405 and S_2 Organization. Respectively, this organization S_3, S_4, S_1, followed by businesses.

4.3. Modeling and Solution of Linear Programming and Distribution Networks

It is aimed to find the optimum solution with linear programming for distribution network between factory, storage locations, and customers.

Established in the model, which is described as factory production sites; Denizli, Egypt and Uzbekistan. Here, the products expected to be sold in Turkey and abroad markets. In this context, the products produced, production, distribution to customers before they reach the appropriate places under the appropriate quantities and storage capacity constraints, there also needs to be shipped to customers by considering customers' demands. In practice, the distribution network model shown in Figure 2. Factory, distribution points and notation used in the description for the products are as follows:

Distribution locations: $D_{İST}$ (İstanbul distribution location), D_{DEN} (Denizli distribution location), D_{BUR} (Bursa distribution location), D_{EUR} (Europa distribution location). *Products:* X_1 (Product1), X_2 (Product2), X_3 (Product3), X_4 (Product4). *Customers:* M_1 (Customer1), M_2 (Customer 2), M_3 (Customer 3). *Factories:* F_{TR} (Turkey factory), F_{EG} (Egypt factory), F_{UZ} (Uzbekistan factory).

Notations used in the model:

X_{ijt} = The amount of product which sent from *i'th* factory to *j'th* distribution location

Y_{jmt} = The amount of product which sent from *j'th* distribution location to *m'th* customer

Z_{it} = *t-th* quantity of products produced in the factory in *i*

C_{ij} = The product's unit transportation cost which sent from *i'th* factory to *j'th* distribution location

C_{jm} = The product's unit transportation cost which sent from *j'th* distribution location to *m'th* customer

C_{it} = Unit production cost of *t'th* product which manufactured at *i'th* factory

D_{mt} = *m'th* customer's demand for *t'th* product

c_j = Capacity of *j'th* distribution location

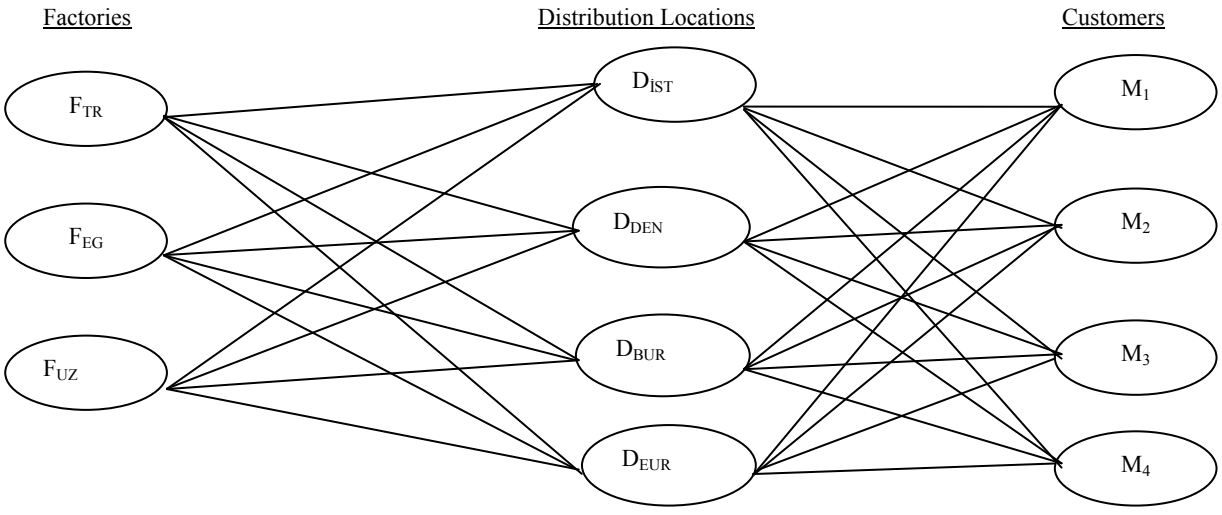

Figure 2. The distribution network model

Linear programming model was created in order to provide operating cost advantages are as follows:

The objective function

$$\text{Min } Z = \sum_i \sum_j \sum_t C_{ij} X_{ijt} + \sum_j \sum_m \sum_t C_{jm} Y_{jmt} + \sum_i \sum_t C_{it} Z_{it} \quad (1)$$

Constraints

$$\sum_i Z_{it} \geq D_{mt} \text{ (Customer demand constraint)} \quad (1a)$$

$$\sum_t X_{ijt} \leq c_j \text{ (The place of storage capacity constraint)} \quad (1b)$$

$$\sum_i X_{ijt} - \sum_j Y_{jmt} = 0, \ \forall_{t,m} \text{ (1. Stage balance constraint)} \quad (1c)$$

$$\sum_j Y_{jmt} - \sum_t Z_{it} = 0, \ \forall_{i,m} \text{ (2. Stage balance constraint)} \quad (1d)$$

$$X_{ijt}, Y_{jmt}, Z_{it} \geq 0 \ , \ \forall_{i,j,m,t} \quad (1e)$$

The unit transportation costs from factories to distribution locations are given in Table 10. The unit transportation costs from distribution location to customers given in Table 11. The unit production costs of products X_1, X_2, X_3, X_4 which produced in factories are given in Table 12. Customers' demands that to be products which collected from distribution centers of certain regions are shown in Table 13. Storage capacity of distribution locations are given in Table 14.

Tablo 10. Unit Transportation Costs (YTL/kg) (From factories to distribution locations)

	Distribution Locations			
Factories	D_{IST}	D_{DEN}	D_{BUR}	D_{EUR}
F_{TR}	2,1	1,6	3	5,5
F_{EG}	7,5	5,8	6,1	4,9
F_{UZ}	4,1	4,5	4,2	2,8

Tablo 11. Unit Transportation Costs (YTL/kg) (From distribution locations to customers)

	Customers			
Distribution L.	M_1	M_2	M_3	M_4
D_{IST}	1,3	3,1	2,6	2,2
D_{DEN}	2,4	4,3	1	3,2
D_{BUR}	1	3,5	2,3	2,5
D_{EUR}	4,1	2,3	3,8	1,7

Table 12. Unit production costs (YTL / kg)

	Factories		
Products	F_{TR}	F_{EG}	F_{UZ}
X_1	4,7	3,4	3,8
X_2	7,3	5,2	5,7
X_3	5,3	4,7	4
X_4	4,9	4,2	4,1

Table 13. The demand for products (tons / month)

Products	**Demands**
X_1	120
X_2	310
X_3	280
X_4	250

Table 14. Storage capacity (tons / month)

Distribution L.	**Capacity**
D_{IST}	1.200
D_{DEN}	800
D_{BUR}	300
D_{EUR}	1.000

Results obtained with the model WinQSB from established model to soluotion of optimal supply distribution network model using the above parameterspresents data and a detailed solution for the problem. In relation to the model, the optimal quantities to be transferred have been identified from factories to distribution locations in the first stage and from distribution locations to customers in the second stage. Also to be produced which was the product, which was the factory, in what quantities was found. For example, the amount of first item that will be moved from the factory in turkey to distribution location in İstanbul must be 120 tons. 120 tons of the product 1 must moved from İstanbul to customer 1. Product 3 must be produced 120 tons in factory of Uzbekistan. All other data associated with the solution shown in Table 15. The total value of the objective function was found to be 10 885 TL in the model that aims to minimize costs.

Table 15. The results of the model

Variable	Value	Variable	Value	Variable	Value	Variable	Value
$X_{TRİST1}$	120	X_{EGEUR3}	120	Y_{DEN32}	120	Y_{DEN34}	120
X_{TRDEN1}	120	$X_{TRİST4}$	120	Y_{EUR22}	120	Y_{EUR24}	120
X_{EGEUR1}	240	X_{TRDEN4}	120	Y_{EUR42}	120	Y_{EUR44}	120
$X_{TRİST2}$	120	X_{EGEUR4}	240	Y_{DEN33}	120	Z_{EG1}	120
X_{TRDEN2}	120	$Y_{İST11}$	120	Y_{BUR13}	120	Z_{EG2}	310
X_{EGEUR2}	240	Y_{DEN31}	120	Y_{EUR23}	120	Z_{UZ3}	280
X_{TRDEN3}	120	Y_{EUR21}	120	Y_{EUR43}	120	Z_{UZ4}	250
X_{TRBUR3}	120	$Y_{İST12}$	120	$Y_{İST14}$	120	Objective	10.885,00

5. CONCLUSION AND RECOMMENDATIONS

Changes in the markets of developed countries in the last quarter of the twentieth century force enterprises to review their costs. So far, it has been seen unavoidable to decrease the cost of activities like unnoticed international shipping, warehousing, inventory control, packaging, re-packaging, labeling, insurance, customs and domestic distribution without losing its quality. From this, the only way to find a solution to different customer needs with competitive prices at optimal periods is to manage supply chain effectively. In this study, various solutions are suggested and implemented to the difficulties resulting from the operational assesment by using primarily SWOT analysis. Supplier selection problem is considered primarily as a result of needs. The solution has been developed by using linear programming that is a strong and clear tool for processing of numerical methods and by using modeling including manufacturing location, warehouse and customers.

Managers must decide taking into account scientific critera for a successful supply chain management. It's known that there are many qualitative and quantitive factors that affect the decision of spplier selection.These factors are considered and by using AHP that is multi-criteria decision-making method, the most suitable supplier is selected among a limited number of alternatives and the features with many different degrees of importance. The solution is found through correct ranking of alternatives from best to worst.

In the last part of study, business is taking production and transporting it to another location and has more than one production place to survive in today's market conditions; As a result of this decision in order to get a cost advantage, it's created a linear programming model inserting increasing transportation costs into the model. Thanks to solving of this model using by WinQSB software programme, it's obtained a global result with a minumum supply chain cost that decide which factory will produce which product and to which distribution center will the products be sent.

In the future studies, customer demands can be established by demand forecasting methods;This established model can be expanded using more data to include avarage inventory turns and also the cost of waiting. The study can be made more useful taking into account how the changes in the paremetres of linear programming with the sensitivity analysis affects optimal solution. Because the obtained optimal solution are valid as long as the problem's parameter values stay fixed. However, the decision-makers know that the optimal solution is not optimal and will change if the parameters change and a new activity adds and the decision-makers want to know to what extent changes will change the optimal solution.

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