3PL Service Provider Selection with a Goal Programming Model Supported with Multicriteria Decision Making Approaches

Evrencan OZCAN* (iD), Merve AHISKALI (iD)

Kırıkkale University, Faculty of Engineering, Department of Industrial Engineering, 71451, Kırıkkale, Turkey

Highlights
• This paper focuses on 3PL service provider selection problem for a foreign trade company.
• A hybrid model is proposed for the best 3PL service provider-order combination.
• It's the first for multimodal international transport with consistent results for relevant problem.

Article Info	Abstract
	In this study, third-party logistics (3PL) service provider selection problem is handled for a foreign trade company that exports the products with high quality level obtained by outsourcing, and who has problems regarding both cost, delivery quality and delivery time. In this direction, 7 criteria are determined for effective evaluation of the performance of the 5 logistics service providers the company is working for and the determination of the most suitable 3PL service provider according to the property of the orders (quantity, mode of conveyance, transportation channel, etc.). The priority levels of service providers are calculated by using these criteria in the combination of Analytic Hierarchy Process (AHP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Then, a goal programming (GP) model that answers the question of which service provider to choose for which order, considering these priority values and the 12 system constraints and 5 objectives that the company encountered in real life is proposed. This model is the first one proposed in the literature for the selection of 3PL service providers for multimodal international transport with consistent results. The model is solved for the current 10 orders using the last 1-year data of the company and the most appropriate 3PL service provider combination is obtained. As a result of the solution of the problem with this methodology, an improvement is achieved about 7% for the rate of delivery on time, 33% for bid - bill consistency rate, and 29% for the problematic delivery rate.

1. INTRODUCTION

The average share of logistics costs (transportation cost, storage cost, inventory cost, order processing cost, procurement, handling, distribution and disposal cost, and customer service expenses [1]) in gross domestic product (GDP) varies 13% in India, 9% in the United States, 10% in the European Union, 11% in Japan, 18% in China, and 16% in Thailand. The fact that logistics costs / GDP ratio is high is seen as a negative situation for the countries' economy. For example, low-level transport infrastructure and logistics service quality increase logistics costs in India. This situation affects the competitive power of the countries negatively in global markets [2]. The level of impact of these important complements of activities, which affect the positions of countries in the global world, is thereby high in enterprises, too. In addition to this, many factors such as globalization, institutional structuring, additional space requirements, changes in logistics management, and labor problems increase the interest in logistics outsourcing. Therefore today, many enterprises focus on their core competencies and direct their logistics functions to 3PL service providers. The outsourcing of logistics activities has made it a necessity to effectively select 3PL service providers [3].

Correspondingauthor, e-mail:evrencan.ozcan@kku.edu.tr

3PL service provider selection is a complex multi-criteria decision-making problem that attempts to optimize more than one objective simultaneously like quality, cost and delivery time. This multi-objective and multi-criteria structure of the problem makes it difficult for decision-makers to work on the problem which have critical importance for the companies and thereby countries [4]. The importance of the issue has necessitated the resolution of the problem despite the complexity of its structure and led the researchers to focus on the selection of the most appropriate 3PL service provider, especially in the last 15 years. Therefore, it is possible to find many studies about the selection of 3PL service provider in the literature. In most studies, selection is made using multi-criteria decision-making (MCDM) techniques such as AHP [5-12], Analytic Network Process (ANP) [13,14], TOPSIS [15], Elimination and Choice Translating Reality (ELECTRE) [3,16] and The Decision Making Trial and Evaluation Laboratory (DEMATEL) [17] or their fuzzy forms [18-24]. In addition, heuristics [25] and statistical methods [26] are also available. Mathematical models [25,27,28] are rarely used to solve the problem. In addition, there are also hybrid models [29-35] in which these approaches are used together. In this context, some examples of studies about the 3PL service provider selection problem as a result of reviewing made on databases such as Science Direct, IEEE, Emerald, Ebsco, Springer and Taylor & Francis are given in Table 1.

Table 1. *Literature overview*

Researchers	Methods	Criteria/Objectives
Kulak, Kahraman [18]	Fuzzy AHP	Transportation cost, error rate, delay rate, flexibility, documentability
Aguezzoul et al. [16]	ELECTRE	Service charge, quality control, firm culture, firm size, on-time delivery, service area, computing performance
Bottani, Rizzi [19]	Fuzzy TOPSIS	Service width, experience, service classification, compliance, financial stability, service flexibility, performance, cost, physical need and knowledge, quality, strategic attitude, trust and honesty
Jharkharia, Shankar [13]	ANP	Long-term operational performance, financial position, risk management
Qureshi vd. [15]	TOPSIS & Interval Data	Capacity, flexibility, quality management, financial stability, compliance, reputation, long-term relationship, balance capacity, business value, service ratio and geographic availability
Göl et al. [5]	AHP	General company evaluation, capacity, quality, customer relations, employee relations
Kasture vd. [20]	AHP & Fuzzy Set Theory	Logistics capacity, logistic service quality, logistic information capacity, potential growth, flexibility
Çakır et al. [21]	Fuzzy TOPSIS	Service cost, financial performance, operational performance, 3PL image, long term relationship
Perçin [29]	AHP & TOPSIS	Strategic factors, business factors, risk factors
Chiang ve Tzeng [22]	Fuzzy AHP	Price, delivery performance, information technology, flexibility to respond to specific orders
Soh [6]	AHP	Finance, service level, relationships, management, infrastructure
Vijayvargiya, Dey [7]	AHP	Cost, delivery, cost of additional services
Barker, Zabinsky [8]	AHP	Costs (recovered material, test costs, scrap), business relations (property information, customer relations)
Özbek, Eren [14]	ANP	Quality, long-term relationship, firm image, operational performance
Daim et al. [9]	AHP	Cost, service quality, information technology, industry experience, local presence
Hwang, Chen [10]	AHP	Service, performance, cost, quality assurance, information technology
Sharma, Kumar [26]	Quality Function Deployment	Wage, industry experience, on-time delivery, assets, capacity utilization, logistics information system, technical integration, optimization capacity, financial growth rate, customer impact,

	(QFD) & Taguchi Loss Function	international scope, ability to meet specific requirements, responsiveness, management level, overall image
Yayla et al. [23]	Fuzzy AHP	Sustainable relationship, service quality, continuous development
Gürcan et al. [11]	AHP	Compliance, long term relationship, financial position, firm image
Govindan et al. [17]	Grey DEMATEL	Service quality, on-time delivery, flexibility in operation, service cost, customer service, logistics information system, financial balance, image, geographic location, technical capacity, performance history, human resources policies
Raut et al. [30]	Data Envelopment Analysis & ANP	Transport fee, fleet capacity, vehicle shape and quality, drive effect, performance, timely transport of vehicles
Bianchini [31]	AHP & TOPSIS	Cost, service level, professionalism, geographic location, experience, innovation capacity and cooperation with customers
Aguezzoul, Pires [3]	ELECTRE I	Service, location, information systems, quality
Singh et al. [35]	Fuzzy AHP & Fuzzy TOPSIS	Transportation and storage costs, logistics infrastructure and storage adequacy, customer service, material loading capacity, quality control, automatic processes, innovation and efficiency, information technologies, flexibility
Kumar et al. [27]	Multi-objective mathematical programming	Minimization of cost, minimization of late delivery, minimization of inability to serve
Ko et al. [25]	Genetic algorithms & mixed integer programming	Cost minimization
Araz et al. [28]	Fuzzy GP & Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE)	Criteria: finance, management, quality, delivery / Objectives: maximization of PROMETHEE values, maximization of accepted orders, maximization of on-time deliveries, minimization of cost
Yuen [12]	Cognitive Network Process & AHP	Location, operation excellence, service quality, price attractiveness
Luk et al. [24]	Fuzzy AHP	Price, time, information technology, flexibility, reliability
Çelik et al. [32]	Fuzzy Grey Relational Analysis & Fuzzy TOPSIS	Cooperation with customer company and its customer, green government regulations, environmental management system, green process design, reduction of energy consumption, green network design
Jain, Khan [33]	TOPSIS & QFD	Ability to collect range of product: ability to manage range of product, ability to store range of product, business ethics, ability to disassemble range of products, disassembly economy, experience in similar products in disassembly process, green policy, commitment, on time delivery, quality, network coverage
Chen et al. [34]	Grey Incidence-TOPSIS & ANP	Service quality, service ability, alliance, cost

According to the literature review for the best 3PL service provider selection problem, 74% of all studies have used MCDM methods, 6% mathematical modeling techniques and 20% used other methods mentioned above. As can be seen from Table 1, while the most commonly used MCDM techniques for this problem in the literature are AHP and TOPSIS, GP is used for the simultaneous optimization of multiple objectives of the problem. This is due to the advantages of the methods mentioned in Section 2, and the focus of the literature on this group of methods is consistent with the multipurpose and multi-criteria structure of the problem. In this context, in this study, the priority values of 3PL service providers are calculated with the combination of AHP and TOPSIS by considering the criteria determined in accordance with the literature and the company facts. Then, maximization of these priority values is included in the objectives to be optimized and in line with the system constraints and other objectives specific to the company, for the first time in the literature, the best 3PL service provider-order combination (consistent with real life) list is obtained by solving the proposed a multi-objective GP model (Figure 1).

In the Section 2 of the study, the methods used in solving the problem are introduced with the reasons for use. After the detailed description of the problem and the details of the solution methodology are presented in accordance with this definition in Section 3, the study is completed with Section 4, which presents the results and recommendations of the study.

2. METHODS

In the literature, MCDM approaches are the most commonly used methods for the 3PL service provider selection problem as mentioned above. Among the MCDM approaches which have many examples such as AHP, ANP, TOPSIS, ELECTRE, DEMATEL and PROMETHEE, the most commonly used methods for this problem are AHP and TOPSIS (Table 1). The main reason for this is that these methods have relative advantages over others. AHP is a method which separates the problems into its components, determines the priorities of the decision makers by using their subjective evaluations and provides a hierarchical structure in line with these priorities. Other advantages of AHP are that decision-makers include assessments of criteria and alternatives at the same time, it does not seek the requirement to make certain that these evaluations and judgments are initially consistent, and that it is possible to evaluate the decision-making process and many different quantitative and qualitative factors that will affect the final outcome. The basis of TOPSIS is to determine the distance of the decision points (alternatives) from the positive and negative ideal solution and to make a ranking among these alternatives. The positive ideal solution (PIS) reflects the desired point of convergence of decision points; on the contrary, the negative ideal solution (NIS) refers to the point to be avoided. In the TOPSIS method, it is accepted that any decision point becomes closer to the PIS as it moves away from NIS, and this increases the preferability of this decision point. Furthermore, it has more simple process than the other outranking algorithms such as ELECTRE, VIseKriterijumsa Optimizacija I Kompromisno Resenje (Multicriteria Optimization and Compromise Solution – VIKOR), Simple Additive Weighting (SAW) and PROMETHEE [33-37].

Finally, GP is a multi-objective optimization method that can choose from an infinite number of alternatives. One of its advantages is that it has the capacity to handle large- scale problems. With this method, the solution of decision problems with multiple objective can be done effectively. Other advantages of the method are that it allows for loose constraints and to develop a suitable solution for infeasible results of the linear programming models. Frequently, GP combined with MCDM techniques such as AHP, TOPSIS, PROMETHEE and ANP to accommodate proper weighting. Thus, it eliminates one of its weaknesses while still being able to choose from infinite alternatives [36].

From this point of view, in this study, according to the best of our knowledge a GP model supported with AHP-TOPSIS combination (to evaluate the priority levels of the 3PL service provider) by considering the multi-criteria and multi-objective structure of the problem to determine the most appropriate order-3PL service provider combination for the first time in the literature in terms of method configuration, consistent results with real life, and considered criteria and objectives.

The application steps of the used methods are presented in Figure 1 briefly. For detailed implementation steps of the methods, see also [38-41].
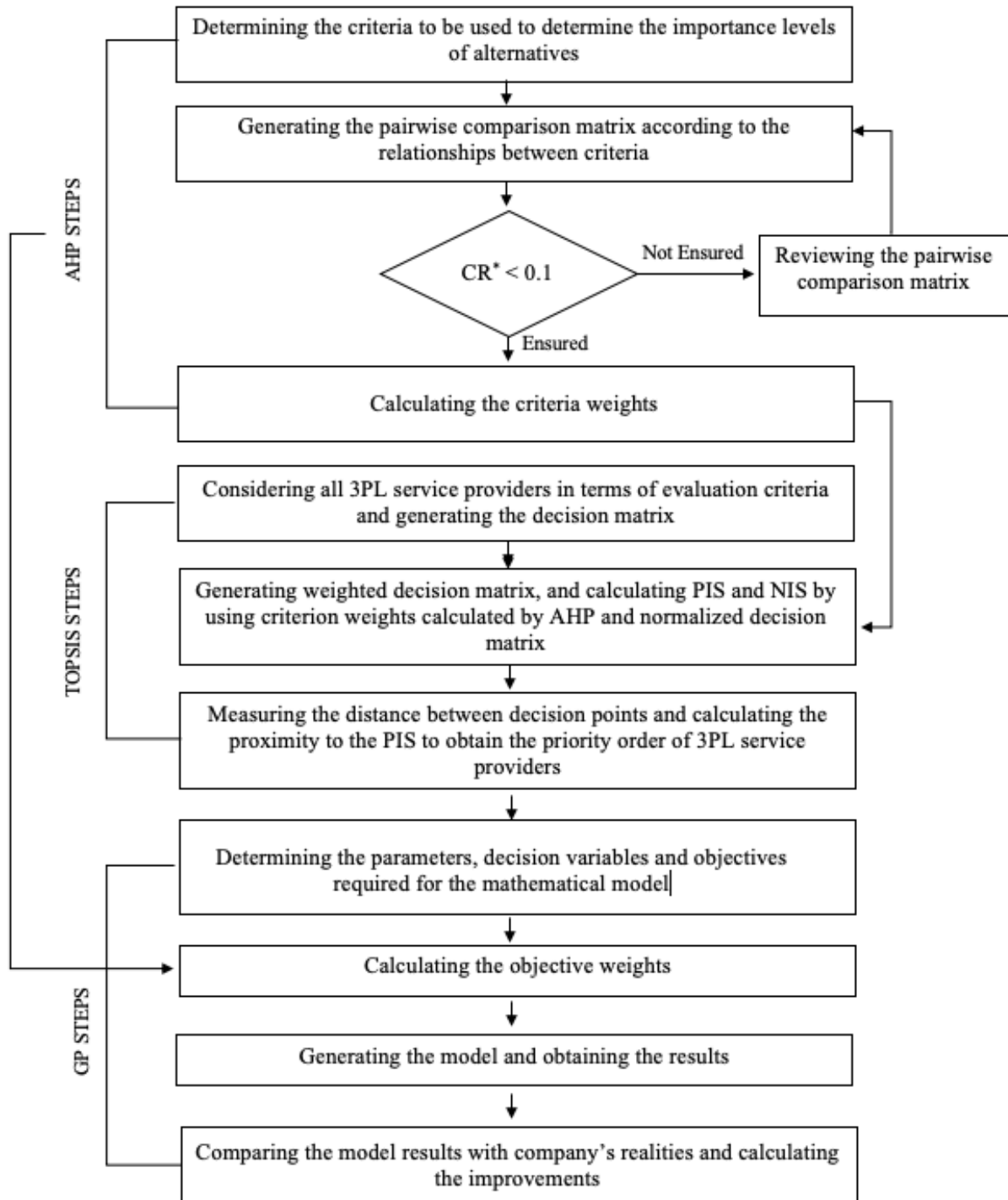
*Consistency Ratio (CR)

***Figure 1.** Application steps*

3. CASE STUDY

In this study, the priority values of 3PL service providers in a foreign trade company are calculated with the combination of AHP and TOPSIS. Then, a GP model is proposed in accordance with the constraints and objectives of the company where these priority values are used for the selection of the most appropriate 3PL service provider. Using last 1-year actual data of company, the model is provided to select the most

appropriate 3PL service provider for per order by resolving in the 12.6.2 version of the IBM ILOG CPLEX optimization software for the current 10 orders.

3.1. Transportation Types Used in the Company's Sendings

Type of transportation consists of express, airline, seaway and highway alternatives. The form of express delivery is most advantageous. Because, both the cost is low, and the customs process is very fast. The constraints of this transportation type are that 150 kg (the final weight after packed) of the gross weight of the order and the sale value is less than 7,500 Euros. If the gross weight of the order is between 150 kg and 400 kg, the type of transport is the airway. When the weight is between 400 kg and 600 kg, it is transported by seaway. When it is more, it is transported by highway. There is no restriction on the sales value of the order for these transportation types. In addition, only the DHL and UPS companies are able to carry out the express transport. The types of transportation (airway, seaway and highway) can perform all companies. As a result, the customer decides on the delivery method of the order.

3.2. Description of the Problem

The operation is done by 3PL service providers, from the factory to the delivery of the products to which it exports, in accordance with the delivery method. For each order, offers are received separately from these companies. In accordance with the offer, the company is dealt with company on the most appropriate price based on the constraints of the company. Estimated package information is sent by the manufacturer of the order whose production is about to be completed. The concept that characterizes the product variety is the weight of the order. That is, the costs vary according to the weight of the order. Offer is requested from each of the 3PL service providers based on this information. Factors related to the order that determines the offer price consist of how packages of the order, dimensions of the package together with the total weight of each package, volumetric weight and information about whether the packages are stackable. The problem will be evaluated as the weight of the order that determines the type of order and the diversity of the order reveals the size of the order. By sending this information to 3PL service providers, estimated prices and transportation plan are received e.g. if the operation is carried out by airway, the firm also transmits the flight plan. The reason for this, process can determine the transportation alternatives in advance and choose the plan that is suitable for the order. Then, the final package detail comes from the manufacturer. The final price is received from 3PL service providers according to the final package information. Moreover, due to some recent problems with the logistics companies, the company wants to comply with some constraints while making this decision. In order to comply with these constraints, the staff members in the logistics department of the company have conducted interviews with all 3PL service providers and determined the rates below:

- On-time delivery rate >= 0.5 (delivery on time)
- Offer-invoice rate of consistency >= 0.4 (is the same or close to the invoice amount after the shipment has been made with the offer of the logistics company)
- Problem experienced delivery rate <= 0.35 (problems caused by the service provider in delivery)

The rate of each firm is determined for these constraints. While determining the rate in the last one year, the jobs worked with that company are taken into consideration. For example, for the delivery rate on time, 30 jobs have been done in 1 year with the company and if the number of works performed on time delivery is 15, the rate is 0.5. Specialist staffs aim to reduce the problems experienced by setting constraints in this way. For the last 1 year, on-time delivery, offer - invoice consistency and delivery rates of 3PL service providers are shown in Table 2.

Table 2. *Performance rates of 3PL service providers*

3PL Service Providers	Number of Worked Together	On-time Delivery Rate	Offer - Invoice Consistency Rate	Problem Experienced Delivery Rate
DHL	30	0.6	0.66	0.16
Bolte	18	0.55	0.61	0.33
DSV	19	0.47	0.57	0.42
UPS	5	0.8	0.5	0.2
TNT	3	0.33	0.33	0.33

The system constraints in the problem addressed are summarized below:

- If the package weight is less than 150 kg, the transportation type must be express only.
- If the order value is below 7,500 Euro, the transportation type must be express only.
- If the package weight is between 151 and 400 kg, the transportation type must be airway.
- If the package weight is between 401 - 600 kg, the transportation type must be seaway.
- If the weight of the package is more than 600 kg, the transportation type must be highway.
- If the transportation type is express, only the companies 1 or 4 can carry.
- Each job can be assigned to only one firm.

The objectives of the problem are minimization of the cost, maximization of the timely delivery rate, maximization of the offer-invoice consistency rate, minimization of the problem experienced delivery rate and maximization of the priority values of the firms. After the order has been approved, the company requires the price of all 3PL service providers according to the order details. The company are working with 3PL service providers which is total 5 named as DHL, Bolte, DSV, UPS and TNT respectively.

In the first phase of the application, the combination of AHP and TOPSIS is used for calculating the priority levels of 3PL service providers.

3.3. Prioritization of 3PL Service Providers

7 criteria are determined according to the literature as well as the criteria specified by the experts in the Logistics Department in terms of the company's experience and facts. These criteria are weighted by AHP method which is frequently used in weighting problems in literature. 5 3PL service providers are prioritized using TOPSIS by using these weights. The criteria discussed in prioritization are as follows;

Speed of responding to offer request: After the orders have been approved, offer request is made from 3PL service providers. Some 3PL service providers are able to late respond to these offer requests. This criterion has been taken into account in the evaluation in order to prevent any problems in planning.

Operational performance: It is very importance for delivering the orders to customers on time. This is related to the operational performance of 3PL service providers. The better the company is well about this subject, the less the problems experienced in delivery.

Accessibility to authorized persons: Some shipments may cause problems during customs or transportation. In such cases, it is only possible to solve the problem faster with authorized persons. Therefore, the expert staff in the company wanted to take this criterion into consideration.

Company image: In this criterion, information such as how the firm dominates the market and the excess experience of similar products are taken into consideration.

Quality: The effectiveness in management and overall performance of the 3PL service provider is taken into consideration and an evaluation is made according to this situation.

Ease of shipment at competitive prices: All 3PL service providers are required price for each approved order. One of the most important factors is to make a comeback at affordable prices of these companies.

Long term relationship: In this criterion, the communication between the 3PL service provider and the company and the information about the shipment of the company are taken into consideration. Tracking and traceability of shipments are two important factors.

Once the criteria and alternatives are determined, the AHP implementation steps are begun. Firstly, the hierarchical structure to weight the criteria affecting the priority levels of relevant 3PL service provider is formed (Figure 2). Then, the pairwise comparison matrix is created. Criteria weights are given in Table 3 and the CR is calculated as 0.023. This means the analysis is consistent.
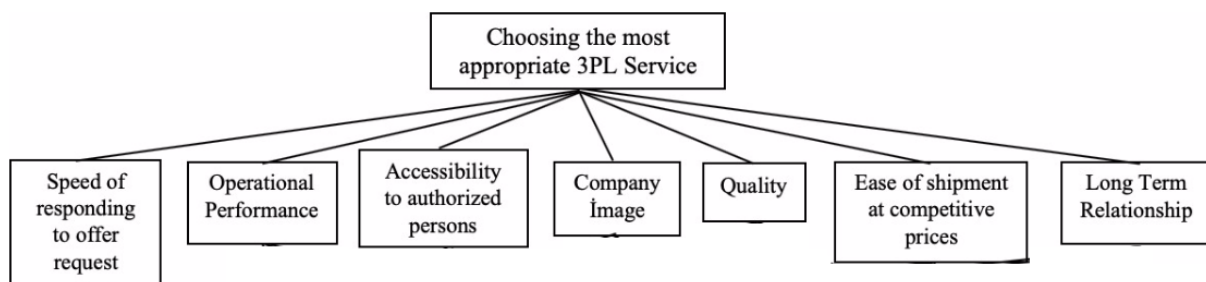

Figure 2. *Hierarchical structure*

Table 3. *Criteria weights*

Criteria	Weights
Speed of respond to offer request	0.0415
Operational performance	0.2646
Accessibility to authorized persons	0.0288
Company image	0.0926
Quality	0.1360
Ease of shipment at competitive prices	0.3746
Long term relationship	0.0620

These criteria weights calculated by AHP are used in the prioritization phase of 3PL service providers by TOPSIS. First, the values of the criteria and the decision matrix of each alternative are established and given in Table 4.

The decision matrix given in Table 4 and the weights of criteria given in Table 3 are applied to the application steps given in Figure 1 and the priority levels of each service provider are calculated and given in Table 5.

Table 4. *Decision matrix*

3PL Service Providers	Criteria						
	Speed of Respond to Offer Request	Operational Performance	Accessibility to Authorized Persons	Company Image	Quality	Ease of Shipment at Competitive Prices	Long Term Relationship
DHL	7	3	5	8	9	10	8
Bolte	3	7	6	4	5	8	3
DSV	5	5	3	1	4	9	2
UPS	9	10	8	6	7	6	5
TNT	6	9	1	2	6	4	4

Table 5. *Priority levels of the 3PL service providers*

Calculation of Proximity according to Ideal Solution	3PL Service Provider
0.5759	DHL
0.5578	Bolte
0.4877	DSV
0.5952	UPS
0.4075	TNT

3.4. Weighted GP Solution

At this stage, the problem of assigning 5 3PL service provider to 10 orders is modelled by minimization of cost, maximization of the on-time delivery rate, maximization of the problem invoice consistency, maximization of problematic delivery rate and maximization of priority levels of the service providers. In the weighted goal programming method, each objective must have a weight. Therefore, expert staff gave value to each objective in the range of 1 to 10 according to the company's and the sector's realities. For weighting the objectives, AHP is used again and the CR of objectives pairwise comparison matrix is calculated as 0.021. According to this consistent analysis, calculated objective weights are given in Table 6.

Table 6. *Objectives' weights*

Objectives	Weights
Cost minimization	0.27
Maximization of on-time delivery rate	0.22
Maximizing the offer-invoice consistency rate	0.13
Minimization of problematic delivery rate	0.19
Maximizing priority values	0.19

According to the problem definition given in Section 3.2, proposed GP model is presented below:

Notations

$k_i = i^{th}$ order weight (kg) $i=1, 2, ..., 10$
$q_i = $ sales value of ith order (€) $i=1, 2, ..., 10$

$c_{ijk} = $ the price for k^{th} type of transportation of jth company to i^{th} order
$i= 1, 2, ..., 10; j= 1,2, ..., 5; k= 1, 2, 3, 4$
$z_j = $ on-time delivery rate of jth company $j= 1,2, ..., 5$
$t_j = j^{th}$ company's offer - invoice consistency rate $j= 1,2, ..., 5$
$p_j = $ delivery rate of the jth company experienced problem $j= 1,2, ..., 5$
$a_j = j^{th}$ company's priority values $j= 1,2, ..., 5$
$W_l = $ weighting of the lth objective calculated by AHP $l= 1, 2, ..., 5$
$d_l^- = $ level below of lth objective value $l= 1, 2, ..., 5$
$d_l^+ = $ exceeding level of the lth objective value $l= 1, 2, ..., 5$

$x_{ijk} = \begin{cases} 1 & i^{th} \text{ order the } k^{th} \text{ realization status with type of transportation of } j^{th} \text{ company} \\ 0 & \text{otherwise} \qquad\qquad i= 1, 2, ..., 10; j= 1,2, ..., 5; k= 1, 2, 3, 4 \end{cases}$

Objective Function

1. Cost minimization ($W_1 = 0.27$)
2. Maximization of on-time delivery rate ($W_2 = 0.22$)
3. Maximizing the offer-invoice consistency rate ($W_3 = 0.13$)
4. Minimization of problem experienced delivery rate ($W_4 = 0.19$)
5. Maximizing of companys' priority values ($W_5 = 0.19$)

$Min\ Z = W_1 * d_1^+ + W_2 * d_2^- + W_3 * d_3^- + W_4 * d_4^+ + W_5 * d_5^-$

Constraints

1. If the package weight is 150 kg and the order value is below 7,500 Euro, the transportation type must be express only.

$\forall i=1, 2, ..., 10 \qquad k_i \sum_{j=1}^{5} x_{ij1} \leq 150$ $\qquad\qquad$ (1)
$\forall i=1, 2, ..., 10 \qquad q_i \sum_{j=1}^{5} x_{ij1} \leq 7,500$ $\qquad\qquad$ (2)

2. When the package weight is between 151 and 400 kg, the transportation type must be airway.

$\forall i=1, 2, ..., 10 \qquad k_i \sum_{j=1}^{5} x_{ij2} \geq 151$ $\qquad\qquad$ (3)
$\forall i=1, 2, ..., 10 \qquad k_i \sum_{j=1}^{5} x_{ij2} \leq 400$ $\qquad\qquad$ (4)

3. If the package weight is between 401 - 600 kg, the transportation type must be seaway.

$\forall i=1, 2, ..., 10 \qquad k_i \sum_{j=1}^{5} x_{ij3} \geq 401$ $\qquad\qquad$ (5)
$\forall i=1, 2, ..., 10 \qquad k_i \sum_{j=1}^{5} x_{ij3} \leq 600$ $\qquad\qquad$ (6)

4. If the package weight is more than 600 kg, the transportation type must be highway.

$\forall i=1, 2, ..., 10 \qquad k_i \sum_{j=1}^{5} x_{ij4} \geq 601$ $\qquad\qquad$ (7)

5. If the type of transport is express, only the companies 1 or 4 can carry.

$\forall i=1, 2, ..., 10 \qquad x_{i11} + x_{i41} = 1$ $\qquad\qquad$ (8)

6. Each job can be assigned to only one firm.

$\forall i=1, 2, ..., 10 \qquad \sum_{j=1}^{5} \sum_{k=1}^{4} x_{ijk} = 1$ $\qquad\qquad$ (9)

7. Minimization of cost target constraint

$\sum_{i=1}^{10} \sum_{j=1}^{5} \sum_{k=1}^{4} c_{ijk} * x_{ijk} + d_1^- - d_1^+ = 8,000$ $\qquad\qquad$ (10)

8. Maximizing of the delivery rate on time target constraint

$\sum_{j=1}^{5} z_j \sum_{i=1}^{10} \sum_{k=1}^{4} x_{ijk} + d_2^- - d_2^+ = 5$ $\qquad\qquad$ (11)

9. Maximizing of offer - invoice consistency rate target constraint
$$\sum_{j=1}^{5} t_j \sum_{i=1}^{10} \sum_{k=1}^{4} x_{ijk} + d_3^- - d_3^+ = 4 \tag{12}$$

10. Minimization of problematic delivery rate target constraint
$$\sum_{j=1}^{5} p_j \sum_{i=1}^{10} \sum_{k=1}^{4} x_{ijk} + d_4^- - d_4^+ = 3.5 \tag{13}$$

11. Maximizing of priority values objective constraint
$$\sum_{j=1}^{5} a_j \sum_{i=1}^{10} \sum_{k=1}^{4} x_{ijk} + d_5^- - d_5^+ = 1 \tag{14}$$

12. $d_j^+ , d_j^- \geq 0$ (15)

$x_{ijk} = 0 \ or \ 1$ (16)

The proposed model is solved by using the company's last one-year data, the most appropriate 3PL service provider for each order is specified in the IBM ILOG CPLEX optimization software for 5 orders, 210 decision variables and 12 constraints under 1 minute available for 10 pcs order. The results obtained as a result of the solution of the model are shown in Table 7 below.

Table 7. *Results of the model*

Order Number	Specified 3PL Service Provider	Specified Type of Transportation
1	UPS	Express
2	Bolte	Airway
3	UPS	Express
4	Bolte	Airway
5	UPS	Express
6	UPS	Express
7	Bolte	Highway
8	Bolte	Airway
9	UPS	Express
10	Bolte	Highway
	Objective Function Value	1,81

The smallness of the obtained objective function value and deviation variables shows that the result of the model is consistent. In order to minimize the cost and minimize the delivery rate, the deviation variable is calculated as "0", which means that the objectives are fully realized. There was a deviation of 5 units while maximizing on-time delivery rate, 4 units while maximizing offer-invoice consistency ratio and 1 unit while maximizing priority values.

The company assigns orders to service providers only on the basis of cost in real life. In this case, the performance of the service providers is ignored. With this study, the most effective method that takes into account the performance of service providers is determined and the cost is minimized. Performance criteria are discussed, and a more analytic result is obtained by using AHP-TOPSIS combination. The determination of more than one objective in the problem and the different importance of these objectives made it necessary to use GP, one of the multi-objective optimization approaches. As a result of the solution of the problem with this method combination, improvements of 7% on-time delivery, 33% on offer - invoice consistency rate, and 29% on problematic delivery rate is achieved.

4. CONCLUSION AND RECOMMENDATIONS

Logistics for companies is one of the most important cost factors and there are many important decision criteria during the selection decision of the 3PL service provider. Therefore, it is very important to choose the methods and algorithms to be used when making this decision. On the basis of all these importance factors, the first time in the literature, a model that demonstrates the results of multimodal international transportation in the transportation sector is proposed, and it is aimed to select the most appropriate 3PL service provider based on the orders of the company being discussed.

In this respect, firstly, AHP-TOPSIS combination was used by aim to determine the level of importance of the 3PL service providers AHP method for the evaluation separately contribution to the main target of all the criteria and the TOPSIS method to make the best choice among the alternatives. 3PL service providers have been selected on the basis of order by resolving the model for the current 10 orders, offering multi-purpose weighted goal programming model aimed at maximizing these priority values, minimizing cost, maximizing delivery rate, minimizing problematic delivery rate and maximizing offer-invoice consistency rate.

As a result of the problem discussed, the reason for cannot commenting improvement on the cost item is that the price of 3PL service providers varies depending on the order weight of each order. In other words, when the weight of the order increases, the cost will increase and in the same way decrease of the weight of order will decrease the cost again. In order to comment on the cost, the orders with the same weight and volume should be assigned. However, due to the realization of the real situation of the company, the realization of the order-based sales and the specific weight and volume of each order, a cost-related improvement rate cannot be given. Considering the improvements, these remarkable findings for the company, in addition to the consistency of the established model, it is seen that 3PL service provider selection contributed to the literature. As the company develops an order-based sales strategy for this problem, orders cannot be divided, and each customer is sent to according to the order. However, considering the future studies by expanding the content of the problem, The aim is to eliminate the lack of literature and to provide more analytical results (Such as determination of supplier and order quantity to be assigned). Due to the fact that it can work with integer, adapt to multi-purpose problems, determine priority values, and break the subjectivity coming from AHP and TOPSIS, it is recommended to solve the problem with Constraint Programming.

CONFLICTS OF INTEREST

No conflict of interest was declared by the authors.

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