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The Study of Multi-Objective Supplier Selection Problem by a Novel Hybrid Method: COA/ε-Constraint

Elham Shadkam[1,*], Mahdi Parvizi[1], Reza Rajabi[1]

Department of Industrial Engineering, Faculty of Engineering; Khayyam University, Mashhad, Iran; e.shadkam@khayyam.ac.ir; mehdi.parvizi17@yahoo.com; Rezarajabi1444@gmail.com.

Abstract

Today, paying attention to the interests of suppliers in supply chain management strategies is one of the important points in the success of long-term and strategic relationships with suppliers. Not paying enough attention to these points sometimes causes irreparable damage to the overall structure of the organization. In response to this need, researchers have developed and proposed different models according to different approaches. This research has presented a special model with the approach of answering these problems. This approach, which is based on the Cuckoo Optimization Algorithm (COA), can solve the problems in multi-objective methods in addition to single-objective problems. This method based on the COA and the ε-constraint method named COA/ε-Constraint. The general approach of this method is to turn a multi-objective problem into a single-purpose problem, which is associated with increased efficiency. The model studied in this paper, with the aim of creating coordination between buyers and suppliers in the problem of supplier selection, is a three-objective model of cost, quality and delivery time, which is implemented to evaluate the performance of the proposed method. The results show the superiority of the proposed method over similar approaches in terms of creating a Pareto frontier.

Keywords: Cuckoo Optimization Algorithm (COA), Supplier selection problem, Pareto frontier, ε-constraint, Hybrid method.

1 | Introduction

The supplier selection problem is not a new problem, and there is a great of research about conceptual and mathematical modeling of these problems. In fact, before developing supply chain management philosophy, many papers can be found as the vendor selection entitled. The research related to supplier selection problem can be seen in the years before 1950 and when linear programming and numerical computation was at the beginning of their work. The first model of supplier selection is used by the National Bureau of Standards in the United States, and its main purpose was to minimize the cost of purchase contracts in the United States defense industries. It should be noted that often review research in the field of supplier selection, have raised the mid-60s as a period of increased attention to the subject provider [1].

For separation of the subject matter of supplier selection issues, various indicators have been proposed in papers such as Aissaoui et al. [1] and De Boer et al. [2]. In conclusion, the content of supplier selection problems is defined in six categories.

- *The number and type of objectives/criteria for supplier selection (single-objective or multi-objective).*
- *Intended timespan (single-period or a multi-period).*
- *The number of parts/raw materials for outsourcing/supplying (one or more pieces).*
- *Existence of discount/payment delay strategies.*
- *Certainty or uncertainty of model variables and parameters.*
- *The system of choosing single-source/multi-source (selecting a supplier or several of them).*

The first time, coordination in the supply chain was proposed by Goyal [3]. This problem was examined in Toptal and Çetinkaya [4]. They discussed and examined changeable intervals for improved cost-effectiveness and the issues that may arise in the coordination planning. Also, the model of Goyal was compared to the model of Taptal, considering the transportation problems [5]. They showed that the rate of improvement was better than the purposes of Goyal's paper and interval change is more significant for improvement. In the paper of Ben-Daya et al. [6], a comprehensive study has been done on specific issues of the joint economic lot sizing problem. The initial investigation has been paying more attention to this type of element, but in recent years, investment to reduce the cost of preparing, considering the variable production costs, quality and process control, uncertain demand, transportation costs, and capacity, expanding the number of entities at all levels and considering problems due dates to joint economic lot sizing problem problems were added.

In the study and classification problems in the field of supply chain coordination, Thomas and Griffin [7] considered the coordination problem between buyers and suppliers as a critical argument in coordination with the operational programs. Also, Tan [8] emphasized the need for integrated management in the areas of purchasing, supply, and logistics.

Leung [9] have examined the supply chain coordination in the centralized and decentralized states. Jafarnejad et al. [10] developed a fuzzy decision-making method for selecting preferred suppliers in a single source state. Criteria are presented as fuzzy triangular numbers, and TOPSIS method is used to solve it. Razmi et al. [11] gave a multi-criteria approach to supplier selection and allocation of the purchase by combining hierarchical process and idealistic planning. In another research, Razmi and Rafiei [12] have used a hierarchical process with a combined mixed integer programming method. Moheb-alizadeh and Faez [13] developed a multi-objective model with multiple criteria of data envelopment analysis. First, they provide efficient solutions to obtain a multi-objective problem of supplier selection. Using data envelopment analysis and taking into account economically efficient solutions as incoming entities, provided the appropriate method for selecting suppliers. Jazemi and Ghodsypour [14] by combining the planning and programming interval compromise, proposed a method called adaptive planning interval for selecting preferred suppliers. Their model is a multi-objective problem that minimizes returns of suppliers and costs and maximizes quality, which is considered as objectives of this problem. Sarmah et al. [15] are considered the coordination between a producer and several buyers with an objective function for minimizing the costs. Amid et al. [16] have developed a supplier selection problem concerning discount strategies. A comprehensive overview of using multi-criteria methods in the selection and supplier evaluation was performed by Ho et al. [17]. Moghaddam [18] examined the problem of supplier selection planning for a piece, as a multi-objective and in fuzzy model. Shadkam and Bijari [19] examined the efficiency evaluation by cuckoo optimization algorithms and simulation for the selection of the supplier's problem in a multi-objective model. Arakaw et al. [20] have used the method of combining general data envelopment analysis and Genetic algorithm to produce efcient frontier in multi-objective optimization problems. Georgestani et al. [21] used data envelopment analysis and the cuckoo meta-heuristic algorithm to form the Pareto frontier. Rajabioun [22] provided the cuckoo optimization algorithm to solve optimization problems. Shadkam et al. [23]

examined the portfolio selection using cuckoo's algorithm. Akbarzadeh and Shadkam [24] examined the problem of production planning using the cuckoo algorithm. Shadkam and Jahani [25] proposed a hybrid method based on COA algorithm and COA/ε-Constraint method. Borhanifar and Shadkam [26] gained the Pareto frontier using the cuckoo algorithm and the simple average weighted methods. From the literature review and research in this area, one finds that the development of models for supplier selection is applicable in three areas:

- *Coordinated Modeling between buyers and suppliers.*
- *The development of multi-objective and multi-product models simultaneously.*
- *Applying uncertain conditions in the supplier selection.*

Concerning this research, in this paper, a model is presented in the supplier selection. The specifications of this model are to take into account the interests between a buyer and a supplier. The problem of coordination in the supply chain is considered, taking into account three objectives between the buyer and supplier in the model. In this case, the final customer raised a certain amount of his needs as demand and Chains of buyers and suppliers to intend to consider three objectives of quality, delivery time, and cost for the entire chain, to meet customer demands. In fact, given the limitations of the problem, they decide which of the providers to meet customer demand and how much to be purchased so that the number of healthy products delivered (indicative target quality) to the final customer with delays of finished products (the true purpose of delivery), and cost of entire chain (indicative target cost) are in optimum balance. Another new issue is raised in this paper, solving using COA/ε-Constraint and obtaining a Pareto frontier using this method. For more information about the COA/ε-Constraint method, refer to Shadkam and Jahani [25].

In the proposed hybrid approach of the simultaneous advantages of both COA and ε-constraint used and leads to an efficient method. On the other hand, it has the speed and accuracy of the COA, and the proposed algorithm can be implemented for large-scale problems. The COA, which was only able to solve single-objective problems, was not used.

In this paper, first the problem is defined and modeled, then the proposed approach is reviewed and validated, and while confirming the necessary efficiency, useful conclusions are presented in this regard.

2 | Presentation of the Model

As mentioned, in the defined model, a buyer is considering to supply the desired products of the final customer, provide a piece of potential suppliers; so that, in this decision-making process, the objectives of cost, quality, and delivery time for both buyers and suppliers must be considered simultaneously at a desirable level of expectations. The specifications of the model will be as follows:

I. The main purpose is planning to ensure the interests of buyers and sellers.
II. Three common objectives are defined as cost, quality, and delivery time between buyers and suppliers.
III. Modeling will be for a period of one year (multi-period).
IV. The problem will be modeled by assuming the absence of discount strategies.
V. All the variables and parameters of the problem are definite.
VI. The annual demand for target customers is constant.
VII. Period order to all suppliers, is the same.
VIII. All suppliers have limited capacity.
IX. The final product is delivered to the customer without delay, and the delay is compensated by spending the extra costs of the buyer.
X. The buyer receives the orders and then determines the failure, corrects, and repairs them at the cost of the supplier.
XI. Orders were received sequentially. This means that after they received the order and entirely using it, the next order is received.

Then, the modeling will be presented, with the definition of variables and factors used.

Parameters.

D: The annual demand of the final product.

n: The number of suppliers ($i = 1, 2, .., n$).

I_i: The percentage of delayed delivery from i_{th} suppliers.

a_i: Percentage of healthy delivery from i_{th} supplier.

c_i: Purchase price from i_{th} supplier.

A_i: Fixed cost of ordering i_{th} supplier.

r: The rates of the annual cost of holding inventory.

z_i: The cost of production (supply) of each original piece by i_{th} suppliers.

s_i: Fixed cost for processing the i_{th} supplier.

G_i: Annual capacity of i_{th} suppliers.

E: Scholarships to suppliers for delay compensation per unit of product.

F: Scholarships to suppliers to compensate for any delay units.

K: The cost of each unit of broken parts which are delivered to the buyer, paid by suppliers.

Variables.

T: Order period (in years).

Q: The total amount of orders to suppliers in each period.

Q_i: Demand predicted by the i_{th} supplier in each period ($\sum_{i=1}^{n} Q_i = Q, Q = DT$).

x_i: The amount of the annual demand of i_{th} which is satisfied by suppliers: ($x_i = \frac{1}{T} Q_i$, $\sum_{i=1}^{n} x_i = D$).

y_i: Binary variable if i_{th} supplier select is equal to 1, otherwise is equal to 0.

According to the definition made, a coordinated multi-objective problem intended by this study is obtained as follows where z_1 shows quality and is defined as "maximizing annually received number of products from suppliers". z_2 is defined to show on delivery time, as "minimizing the number of received goods with a delay from suppliers. z_3 is defined as the total cost of the chain that this cost is equal to the total annual costs of suppliers and annual cost of the buyers, as *Table 1*.

Table 1. The costs of the mentioned model.

$\sum_i c_i x_i$: purchase cost	$\sum_i z_i x_i$: buying cost
$\frac{D}{Q} \sum_i A_i y_i$: delivery cost	$\frac{D}{Q} \sum_i s_i y_i$: preparation cost
$\frac{rQ}{2D^2} \sum_i c_i x_i^2$: inventory cost	$E \sum_i l_i x_i$: overhead costs
$F \sum_i l_i x_i$: delay suppliers' cost	$K \sum_i (1 - \alpha_i) x_i$: delivery defective parts cost

According to the above, the objective functions and constraints of the model can be obtained as follows:

$$\text{Max } z_1 = \sum_i \alpha_i x_i , \tag{1}$$

$$\text{Min } z_2 = \sum_i l_i x_i , \tag{2}$$

$$\text{Min } z_3 = \sum_i (c_i + z_i + (E + F)l_i + K(1 - \alpha_i))x_i + \frac{rQ}{2D^2} \sum_i c_i x_i^2 \times \frac{D}{Q} \sum_i (A_i + S_i)Y_i, \tag{3}$$

$$\text{s.t: } \sum_i^n x_i = D, \tag{4}$$

$$0 \leq x_i \leq G_i \quad \forall i = 1,2 \dots n, \tag{5}$$

$$x_i \leq DY_i \quad \forall i = 1,2 \dots n, \tag{6}$$

$$x_i \geq \varepsilon Y_i \quad \forall i = 1,2 \dots n, \tag{7}$$

$$Y_i = \{0,1\} \quad \forall i = 1,2 \dots n. \tag{8}$$

Eq. (1) and *Eq. (2)* is clear, but how to achieve the *Eq. (3)* is described below. It is clear that the average inventory level of the buyer in the purchase of i_{th} supplier is equal to $\frac{1}{2}T_iQ_i$. Considering the current fixed rate of inventory by the purchaser and placement of T, the average inventory level of the buyer to purchase from the i_{th} supplier is equal to $\frac{1}{2}\frac{Q_i^2}{D}$. By applying inventory cost and the cost of buying from the i_{th} supplier, the total annual cost of inventory to buyers is equal to $\frac{rQ}{2D^2} \sum_i c_i x_i^2$. *Eq. (4)* are used to satisfy demand, *Eq. (5)* to consider capacity for suppliers, and *Eq. (6)*, *Eq. (7)* and *(8)* to explain the logical relationship between x and y. In recent relations, ε is a sufficiently small amount. The functions, z_1 and z_2, do not have variable Q, and they are linear functions, but objective function z_3 is a non-linear function that comes with the derivation towards Q.

$$\frac{\varrho Z_3}{\varrho Q} = 0 \qquad \Rightarrow \qquad Q^* = \sqrt{\frac{2D^3 \sum_i (A_i + S_i)Y_i}{r \sum_i C_i x_i^2}}.$$

By substituting this value, the model changes as follows:

$$\text{Max } z_1 = \sum_i \alpha_i x_i , \tag{9}$$

$$\text{Min } z_2 = \sum_i l_i x_i , \tag{10}$$

$$\text{Min } z_3 = \sum_i (c_i + z_i + (E + F)L_i + K(1 - \alpha_i))x_i + \sqrt{\frac{2r}{D}} \sum_i (A_i + S_i)Y_i \times \sqrt{\sum_i C_i x_i^2}, \quad (11)$$

$$\text{s.t.} \quad \sum_i^n x_i = D, \quad (12)$$

$$0 \leq x_i \leq G_i \quad \forall i = 1,2 \dots n, \quad (13)$$

$$x_i \leq DY_i \quad \forall i = 1,2 \dots n, \quad (14)$$

$$x_i \geq \varepsilon Y_i \quad \forall i = 1,2 \dots n, \quad (15)$$

$$Y_i = \{0,1\} \quad \forall i = 1,2 \dots n. \quad (16)$$

3 | The Hybrid Proposed Method

The multi-objective optimization problems often are not possible to obtain a solution that simultaneously optimizes all the objectives of the problem, so using the Pareto frontier, an acceptable solution to a multi-objective problem could be obtained. To solve the problem of selecting suppliers, we first give a solution method to the multi-objective problem called ε-Constraint and then using the meta-heuristic cuckoo algorithm, and combination with the above method (COA/ε-Constraint), we have gained the Pareto frontier that went on to explain the procedure described above [25].

3.1 | Introducing the Cuckoo Optimization Algorithm

This algorithm is one of the newest and most powerful evolutionary optimization methods that have been introduced so far. Cuckoo algorithm, inspired by the lifestyle of a bird called the cuckoo in 2009 presented by Shin Ouyang and Deb Savash, in 2011 was developed by Rajabioun [22]. The cuckoo optimization algorithm flowchart is as *Fig. 1*:
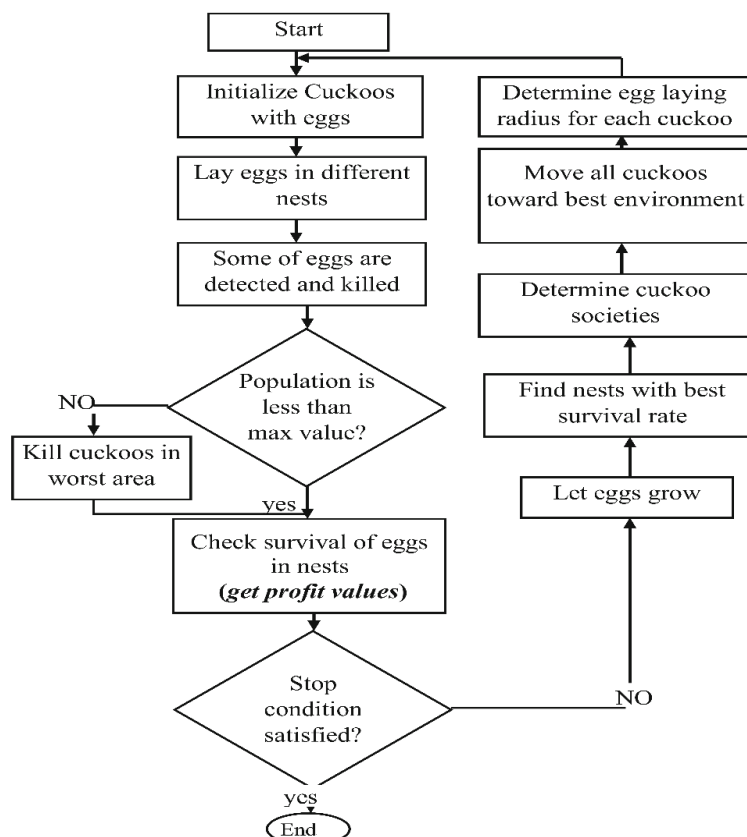

Fig. 1. The flow chart of the cuckoo optimization algorithm [22].

3.2 | The Implementation of the Propose Hybrid COA/E-Constraint Method

Given that the ε-Constraint method is used in multi-objective problems and thus acts as follows: it keeps one of the objective functions as the main objective and puts other objective functions as a part of the restrictions. For this purpose, functions $\sum_{i=1} \alpha_i x_i$ and $\sum_{i=1} l_i x_i$ in the Lingo software programming onetime with min and once with max until upper and lower limit for this objective to be obtained to implement the method of ε-Constraint.

Upper and lower limits of mentioned objective functions, was achieved as follows:

$$20 \le \varepsilon_1 \le 132.2, 1900.2 \le \varepsilon_2 \le 1972.7$$

The conversion mode of a three-objective model to a single model is expressed as follows.

$$\text{Min } z_3 = \sum_i (c_i + z_i + (E + F)L_i + K(1 - \alpha_i))x_i + \sqrt{\frac{2r}{D} \sum_i (A_i + S_i)Y_i} \times \sqrt{\sum_i C_i x_i^2}, \qquad (17)$$

$$\text{S.t.} \quad \sum_i \alpha_i x_i \ge \varepsilon_2 , \qquad (18)$$

$$\sum_i^n l_i x_i \le \varepsilon_1, \qquad (19)$$

$$\sum_i^n x_i = D, \qquad (20)$$

$$0 \le x_i \le G_i \quad \forall i = 1,2 \dots n, \qquad (21)$$
$$x_i \le DY_i \qquad \forall i = 1,2 \dots n, \qquad (22)$$
$$x_i \ge \varepsilon Y_i \qquad \forall i = 1,2 \dots n, \qquad (23)$$
$$Y_i = \{0,1\} \qquad \forall i = 1,2 \dots n. \qquad (24)$$

In this model, the problem is dealt with 10 suppliers (n =10) and the demand equal to 2,000 units (D = 2000) with the assumption that: E=65, F=35, K=40, r=0.25, $\varepsilon = 10^{-14}$, other parameters of this model are as *Table 2*.

Table 2. The parameters of the model.

Supplier Number	C_i	L_i	α_i	G_i	Z_i	A_i	S_i
1	112	0.05	0.98	570	93	7450	9800
2	118	0.08	0.94	670	89	6120	6400
3	114	0.02	0.96	450	90	6590	8600
4	117	0.04	0.97	590	91	6890	9300
5	119	0.01	0.97	610	90	6410	8970
6	120	0.01	0.99	590	89	6700	9100
7	111	0.07	0.95	640	92	6300	9500
8	115	0.05	0.96	470	86	7100	9210
9	108	0.01	0.98	360	88	7800	9700
10	127	0.01	0.99	680	86	6320	9460

As can be seen, the number of initial solution devices will vary depending on the number of suppliers. In the COA, the initial direction is created based on the location of the cuckoo, which is similar to the chromosome in the genetic algorithm and will be as follows.

The initial solution consists of 5 main parts based on *Fig. 2*. The first part is related to the order period, the second part is related to the total number of orders to suppliers in each period, and the third part is related to the demand estimated by the ith supplier, which consists of one part. Similarly, the fourth and fifth sections are formed by each of the i-classes, the fourth section shows the amount of annual demand supplied by the supplier i and the fifth section represents the variables zero and one, which if the supplier is selected, i is the value of one.

T	Q	Q_1	...	Q_n	x_1	...	x_n	y_1	...	y_n

Fig. 2. Chromosome structure of the cuckoo algorithm.

In order to identify the most effective parameters on the problem, the effect of each parameter on the elapsed time is investigated. The results in *Fig. 3* show that D and n parameters are most effective.
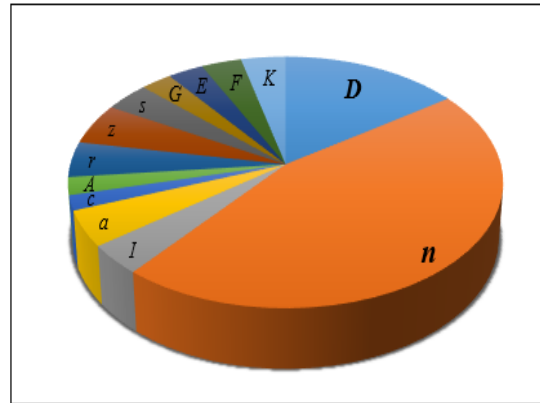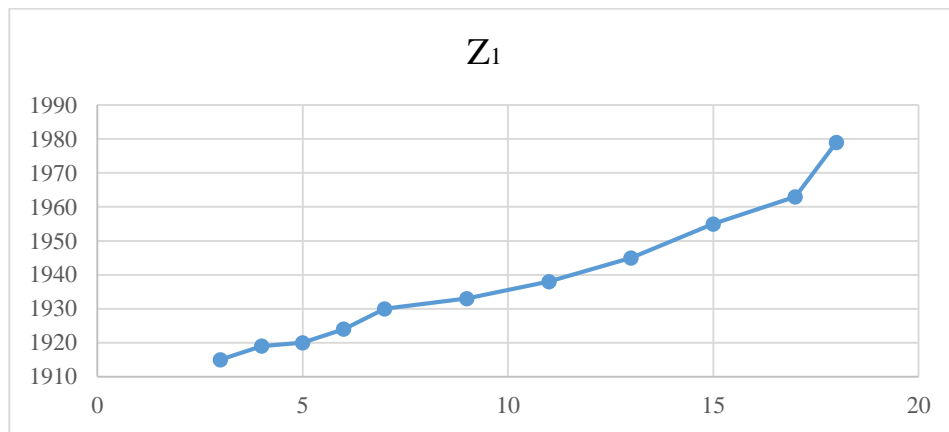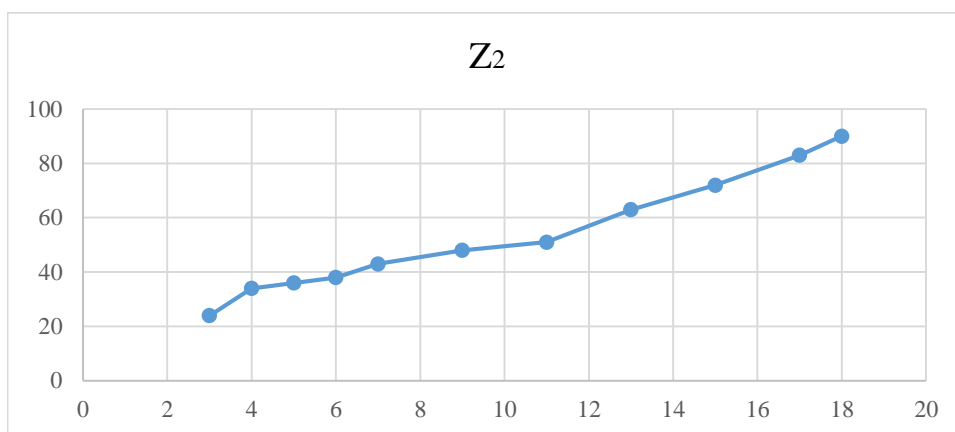

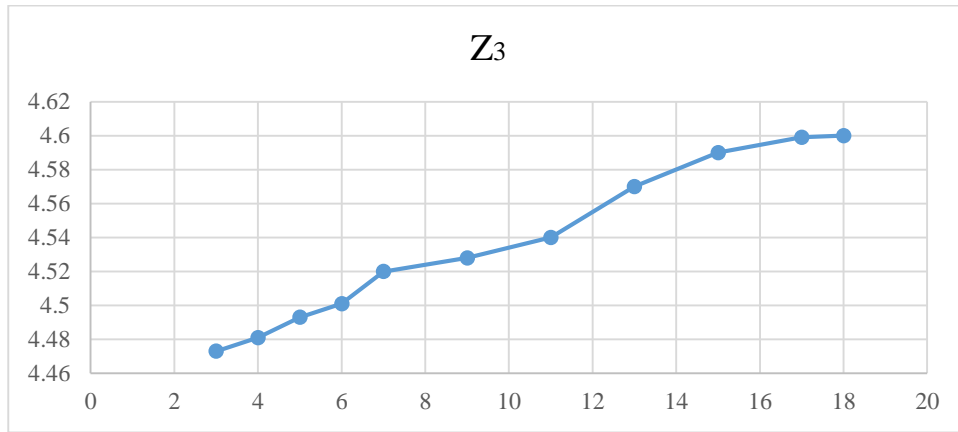**Fig. 3. The effect of each of the problem parameters on the elapsed time.**

Considering that D and n are the most effective parameters of the problem, then in *Fig. 4* and *Fig. 5*, the effect of this parameter on each of the objective functions is investigated. As can be seen, by increasing these two parameters, the values of all three objective functions increase and there is a consistent relationship between these parameters and the objective functions.


a

b

c

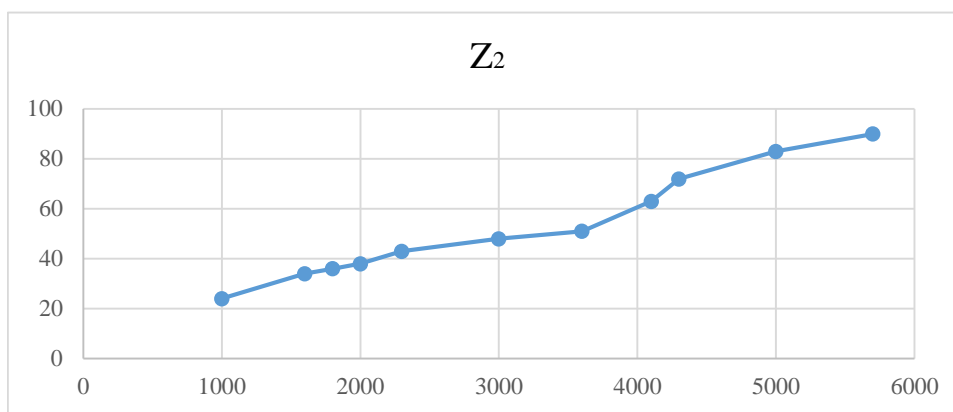**Fig. 4. The effect of n parameter on objective functions.**

Also, the effect of these two parameters on the problem decision variables has been investigated and the results are shown in *Table 3*. As can be seen, suppliers 1, 2 and 4 are selected in each case and the suppliers are with the desired performance. In the next category, suppliers 6 and 7 are good and other suppliers do not perform well and are usually not selected.

**Table 3. The effect of D and n parameters on decision variables.**

| n	D	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	y_{10}
3	1000	358	275	367								1	1	1							
4	1600	1050	550	0	0							1	1	0	0						
5	1800	805	589	0	406	0						1	1	0	1	0					
6	2000	987	679	0	265	0	69					1	1	0	1	0	1				
7	2300	1100	599	0	392	0	130	79				1	1	0	1	0	1	1			
8	2500	1240	772	39	299	0	59	91	0			1	1	1	1	0	1	1	0		
9	3000	2035	398	21	300	0	79	32	0	135		1	1	1	1	0	1	1	0	1	
10	3300	2290	398	56	397	0	96	39	0	24	0	1	1	1	1	0	1	1	0	1	0
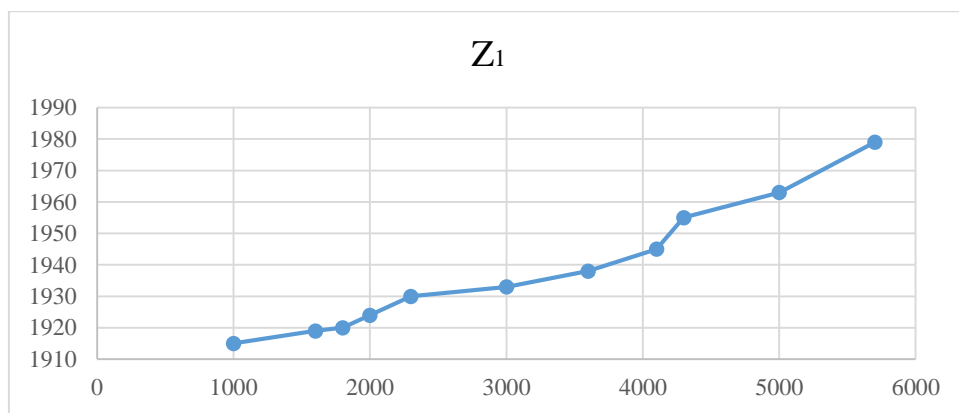
a

b
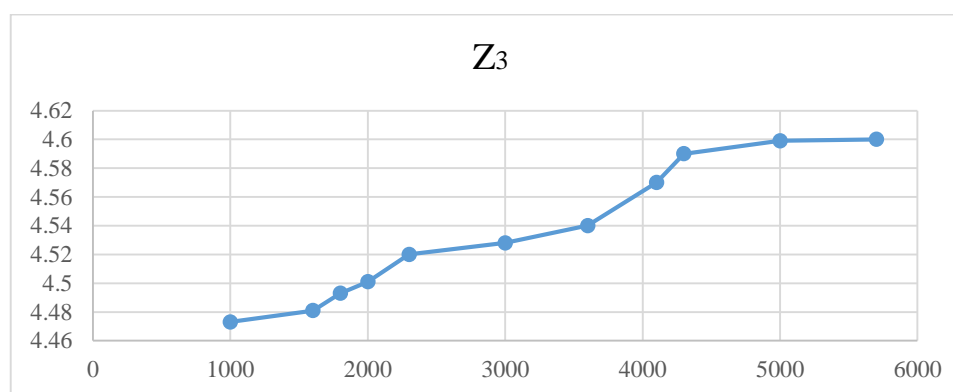
c

Fig. 5. The effect of D parameter on objective functions.

In the continuation of the sensitivity analysis process, in addition to the effective parameters of the problem, the effective parameters of the cuckoo optimization algorithm are also identified, which are number of clusters, initial number of cuckoos, max number of cuckoos, min number of eggs, and max number of eggs. The number of parameters is very important and effective in the performance of meta-heuristic algorithms, which is usually obtained experimentally. In *Fig. 6*, it can be seen that by examining the different values of the number of clusters parameter on the value of the objective integration function of the problem, the best value for this parameter is identified. This process is performed similarly for the other parameters and the results are shown in *Table 4*.

a

b

c
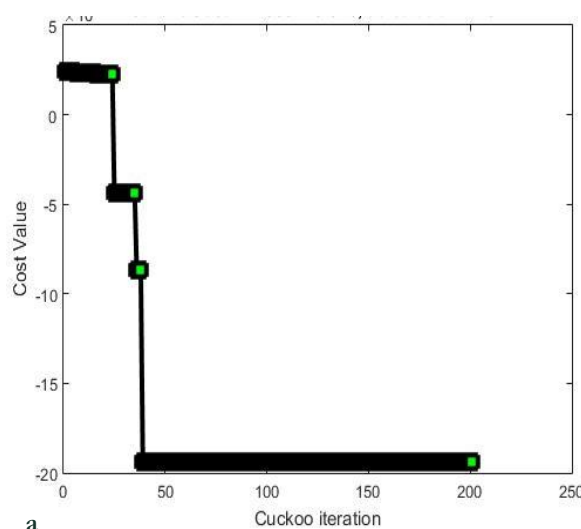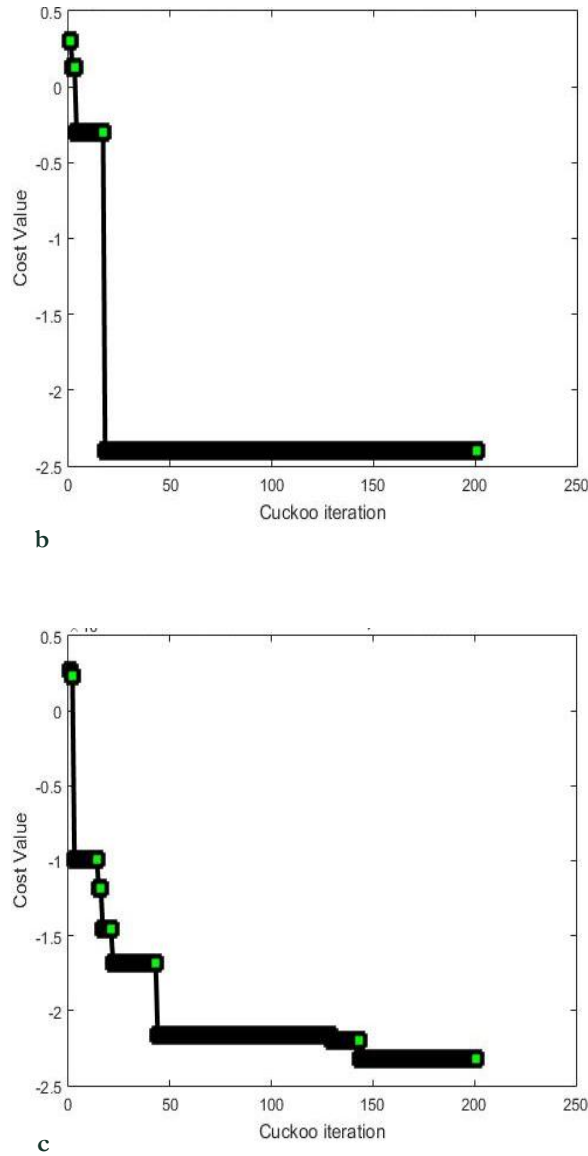
Fig. 6. The effect of changing the number of clusters on the value of the integration function: (a) The number of clusters=4, (b) the number of clusters=3, the number of clusters=2.

Table 4. Optimal values of the cuckoo meta-heuristic algorithm parameters for the proposed logistics problem.

Parameter	Value
Number of clusters	4
Initial number of cuckoos	4
Max number of cuckoos	20
Min number of eggs	3
Max number of eggs	5

Now, to obtain the Pareto frontier, using the proposed hybrid method by MATLAB software repeated in 1000 iterations with 0.725 strike length for ε_2 and 11.22 for ε_1 parameters, the Pareto frontier can be obtained as *Fig. 7*. Also, the values of the decision variables and the objective functions are shown in *Table 5*.
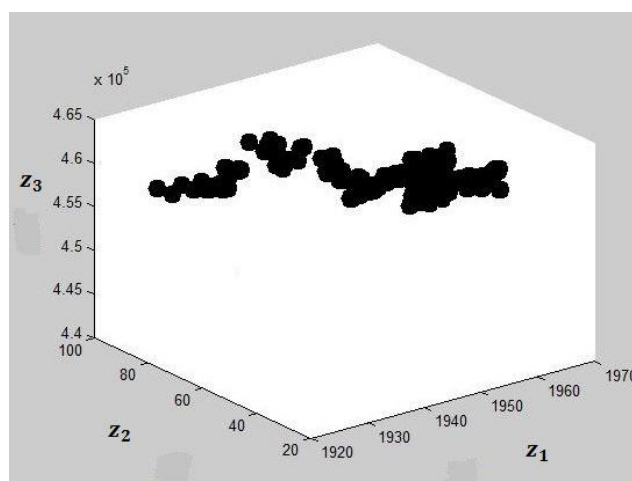
Fig. 7. The Pareto frontier obtained by using the COA/ɛ-Constraint method for ten suppliers.

Table 5. The Results of implementation of the proposed method.

n	3	4	5	6	7	8	9	10
D	1000	1600	1800	2000	2300	2500	3000	3300
X$_1$	358	1050	805	987	1100	1240	2035	2290
X$_2$	275	550	589	679	599	772	398	398
X$_3$	367	0	0	0	0	39	21	56
X$_4$		0	406	265	392	299	300	397
X$_5$			0	0	0	0	0	0
X$_6$				69	130	59	79	96
X$_7$					79	91	32	39
X$_8$						0	0	0
X$_9$							135	24
X$_{10}$								0
Y$_1$	1	1	1	1	1	1	1	1
Y$_2$	1	1	1	1	1	1	1	1
Y$_3$	1	0	0	0	0	1	1	1
Y$_4$		0	1	1	1	1	1	1
Y$_5$			0	0	0	0	0	0
Y$_6$				1	1	1	1	1
Y$_7$					1	1	1	1
Y$_8$						0	0	0
Y$_9$							1	1
Y$_{10}$								0
Z$_1$	1915	1919	1920	1924	1930	1933	1938	1945
Z$_2$	24	34	36	38	43	48	51	63
Z$_3$	4.473	4.481	4.493	4.501	4.52	4.528	4.54	4.57

In this paper, in addition to three-dimensional Pareto frontiers, we have drawn pairwise Pareto frontiers for this reason that, if we do not consider one of the objective functions, we would have the Pareto frontier of the other two functions towards to each other, for example, if the only objective is quality and cost, and we do not consider delivery time, Pareto frontiers of two functions towards each other are like as *Fig. 8-10*. It is worth noting that due to the boundaries related to the values of the objective function, the origin of the coordinates in *Fig. 7* to *Fig. 10* has been changed to have a clearer shape

In order to validate the method of the article, in addition to the proposed method, the exact method has also been used. The results are presented in the *Table 6* in two ways of exact and meta-heuristic methods. In both methods, the final solutions are obtained for the value of the objective function with approximately 0.1; but the elapsed time of exact method was much longer than proposed method. MATLAB software has been used to code the required programs. It should be noted that for n greater than 18, due to the non-responsiveness of the memory system and the length of time, it is not possible to count the total number of cases with ordinary computers. The same phenomenon that can be seen with the proposed method can be found in less time to a very near solution to the result obtained by solving the exact method.
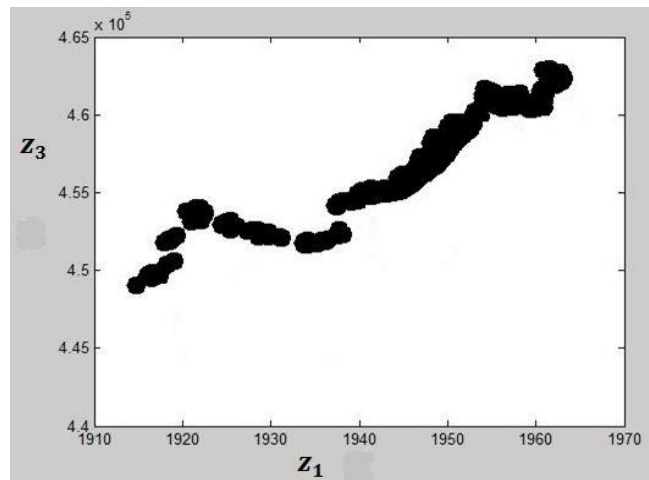

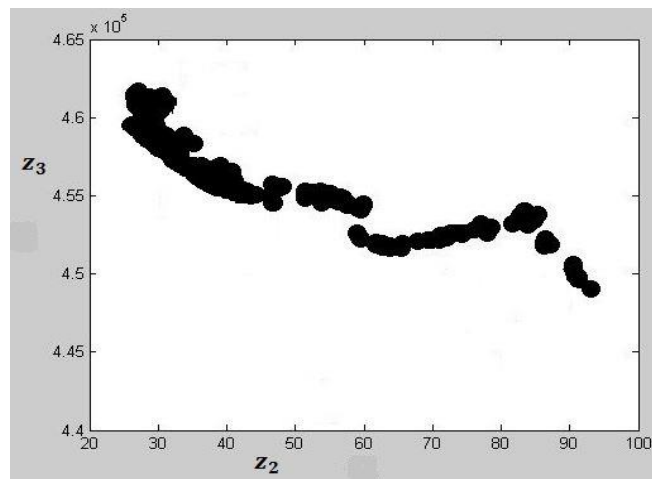**Fig. 8. Quality Paret o frontier, towards the cost.**

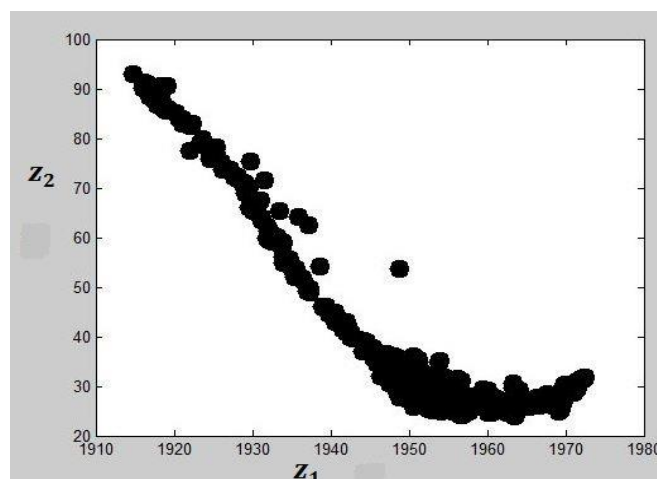**Fig. 9. Pareto frontier for the cost of delivery time.**

Fig. 10. The Pareto frontiers of quality towards the delivery time.

Table 6. Comparison of exact method and proposed approach.

n	D	Elapsed Time (Sec)	
		Exact	Proposed approach
3	1000	2.79	2.21
4	1600	2.97	2.74
5	1800	2.42	2.03
6	2000	3.12	2.26
7	2300	5.37	2.24
9	3000	13.752	2.27
11	3600	61.45	2.57
13	4100	319.18	2.64
15	4300	1937.4	3.32
17	5000	8114.35	3.7
18	5700	9977.52	3.68

4 | Conclusion

This research; in general, it was done with the aim of optimizing the needs of suppliers and buyers and examining the problems in a multi-objective problem; Due to the general problems in other previous studies, including the existence of some inefficiencies, the problem-solving approach in this study is a solid approach based on problem solving using the cuckoo optimization algorithm; Which eventually led to the creation of an optimization problem model called the COA/ε constraint method.

The main objectives of the problem are to establish a coordination between the three components considered by suppliers, namely quality, cost and delivery time, which we finally achieved an optimal output by implementing the COA/ε-constrain method and creating Pareto frontiers; The proposed method was able to achieve good efficiency in achieving the optimal solution and play a good role in optimizing multi-objective supply chain problems. Therefore, it is suggested to use obtained in general problem of supplier selection and in other similar studies to be studied by researchers. It is also suggested to use other approaches of multi objective decision method such as STEM method and Goal Programing in solving.

Conflict of Interest

The author has no conflicts of interest to declare that are relevant to the content of this article.

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