The Simulation of the Supply Chain in an Investment Company by Genetic Algorithm and PSO

Ali Hamdollahzadeh[1]| Mohammad Ali Arjamfekr[2]

[1]M.A Student, Industrial Engineering System Management & Productivity, School of Industrial Engineering, Firoozkooh Branch, Islamic Azad University, Tehran, Iran.
[2]B.A Student of Industrial Engineering, School of Industrial Engineering, Qazvin Branch, Islamic Azad University, Tehran, Iran.

ABSTRACT

Nowadays, the supply chain is considered as the most effective element among the economic and manufacturing enterprises and the reason of its foundation is the increase of the pressures by the customer demands on high quality and quick service. Time management in the supply chain causes quick service and the enhancement of customers' satisfaction level that is the most important component for managing waiting reduction time. After the selection of the suitable supplier, the amount of optimal order of each one of the suppliers must be obtained, implementing using the multi-objective planning models. Thus the purpose of this study is to investigate the simulation of the supply chain in an investment company by genetic algorithm and PSO. This work is done using the multi-objective model design, with the purposes of reducing existing costs in chain, as well as maximizing the purchased material's quality from the suppliers. Finally, the model is solved using Multi-Objective metaheuristic Method of anonymous ordering Genetic Algorithm and In order to validate the model, the particle mass optimization algorithm was also solved and the results were compared with the first method.

Keywords: Supply Chain, Investment Company, Genetic Algorithm, PSO.

I. INTRODUCTION

In the current competitive environment in the world, the secret of the survival of organizations is to interact effectively with each other so that they can respond to the diverse demands of their clients with the characteristics of the production environment of the present. In this regard, organizations intend to achieve more effective strategic goals by working together. With the communication of organizations, activities such as location, supply and demand planning, product and inventory maintenance, that are all implemented in the company level, are transferred to supply chain levels (Lakzian and Dehghani, 2010). In general, the purpose of supply chain is to provide services and products to the final customer through the establishment of relationships between affiliated organizations that are directly or indirectly related to meet the customer needs (Burer et al., 2008). Thus, for the integration of materials, information and finances between

organizations in the supply chain of a new management philosophy, called Supply Chain Management (Stadtler&Kilger, 2000).

Supply chain management can be divided into three categories of supply chain design, supply chain planning, and supply chain control (Shankar et al., 2013). Location and allocation decisions can help supply chain management in design with the selection of facilities, the selection of suitable places for the construction of facilities, the selection of suitable locations for the construction of a facilities and the selection of network of distributors. Also, how much each company produces, how much the raw material they receive from the suppliers and how much the product they send to each distributor will help supply chain management in planning. Accordingly, location and allocation decisions can be considered as one of the most important issues in supply chain management that helps managers to make effective and efficient decisions.

The selection of supplier and the determination of the optimal amount of order is one of the important components of production and logistics management for many of the countries (Geringer, 1988). If the processes are selected correctly, the high quality and the long-term stable relations will be more achievable. the circumstance of relation with the environment and the strategy of relationship with other companies are related to each other (Aissaoui et al., 2007). Also, the wrong selection of a supplier can lead to a reversal of the financial and operating position of a company and, on the other hand, the correct selection of the supplier or the determination of the optimal order can reduce the cost of purchasing, improve market competitiveness and promote the consumer's satisfaction. The optimum amount of order in the production planning can play a very important role, although it also influenced by production planning (Garfamy, 2006).

Cebi and Bayraktar (2003) integrated the data for allocating order among suppliers, lexicographic idealistic planning and data hierarchical analysis process together. The purpose of their model is to maximize the quality level of the purchased goods, minimize the cost function, and maximize utility function. The considered limitations by them include the full satisfaction of buyer's demand and meet the maximum and minimum values of the order for each supplier and each item. the applied criteria by as well them included logistic, technologic, commercial, and communicative criteria (Cebi, 2003).

In 2005, Xia and Wu integrated the hierarchical process of improved data by the rigid collections theory with the planning of mixed integer in order to simultaneously determine the number of suppliers and allocate between them in the multiple sourcing mode, the existence of several criteria and considering supplier constraints. They assumed in their model that the basis of quantity or diversity was the purchased products. To further describe the model, the algorithm of solution and two numerical examples are presented (Xia & Wu, 2005).

II. Methodology

In this research, the model parameters are adjusted based on the information existed in a health products company and after that the restrictions are adjusted according to the opinion of company managers and also its current situation and the ultimate model was designed. In the field of quality level which is considered as the second purpose from the existing information of the quality control section of the company, among the results of numerous experiments on the raw materials purchased from each supplier, as well as the quality charts related to the quality of each raw material, the rate of quality level is estimated and included as parameters of the second objective function in the model.

Hypotheses about the planning model

- multi-product

- multi-period

- existence of multiple suppliers for each product separately

- warehouse capacity limitation

Final model
1

$$Min \, Z_1 = \sum_i \sum_j \sum_t P_{ij} \, X_{ijt}$$
$$+ \sum_i \sum_j \sum_t O_{ij} \, e^{(-\beta_j \sum_{k=1}^t Y_{ijk})} Y_{ijk}$$
$$+ \sum_i \sum_j \sum_t \frac{1}{2} h_i X_{ijt}$$
$$+ \sum_i \sum_{t-1} \frac{1}{2} h_i \left(\sum_{k=1}^{t-1} \sum_j X_{ijk} - \sum_{k=1}^{t-1} d_{ik} \right)$$
$$+ \sum_i \sum_j \sum_t T_{ij} \left[\frac{s_i X_{ijt}}{V_{ij}} \right]$$

2

$$Max\ Z_2 = \sum_i \sum_j \sum_t F_{ij} \cdot e^{\lambda ijt}\ X_{ijt}$$

Constraints:

1)

$$\sum_{k=1}^{t} \sum_j X_{ijk} - \sum_{k=1}^{t} d_{ik} \geq 0\ for\ all\ i\ and\ t$$

2)

$$\sum_{t=1}^{T} \sum_j X_{ijt} - \sum_{t=1}^{T} d_{it} = 0\ for\ all\ i$$

3)

$$\sum_i \sum_j \sum_t s_i X_{ijt} + \sum_i \sum_{t-1} s_i \left(\sum_{k=1}^{t-1} \sum_j X_{ijk} - \sum_{k=1}^{t-1} d_{ik} \right)$$
$$\leq S\ for\ all\ t$$

4)

$$X_{ijt} \leq C_{ij}\ for\ all\ i, j\ and\ t$$

5)

$$X_{ijt} \leq M.Y_{ijt}\ for\ all\ i, j\ and\ t$$

6)

$$Y_{ijt} = 0\ or\ 1\ for\ all\ j\ and\ t, X_{ijt} \geq 0\ for\ all\ i, j\ and\ t$$

i: number of products

j: number of suppliers

t: number of courses

X_{ijt}: the number of the order of product i from the supplier j in the course t

Y_{ijt}: the variables 1 and 0. If it is ordered for product i to the supplier j in the course t it is 1, otherwise it is 0.

P_{ij}: net purchase cost of product i from the supplier j

O_{ij}: the cost of order for the supplier

T_{ij}: the cost of transportation for the supplier j in each vehicle

hi: the cost of maintenance for the product i in each course

d_{it}: the demand of product i in each course t

f_{ijt}: the quality level of the ordered product i from the supplier j in the course t

λ_{ij}: the quality level growth rate of the ordered product from the supplier j

β_{ij}: the rate of order cost reduction for the supplier j

C_{ij}: the capacity of each supplier in the production of product i

si: the space that product i occupies

V_{ij}: the capacity of the vehicle of supplier j

S: the total warehouse capacity

Model solution

Some of the problems are so complicated that common solutions cannot be used to find the optimal answer, but the satisfactory answer should be sufficed. In these cases, innovative methods can be used that are based on a series of rational ideas and do not necessarily seek optimal response. But metaheuristic methods provide a special innovation to fit a specific type of problem. These methods are used to find optimum arrangement.

The genetic algorithm includes designing the individuals of the early communities, choosing from the best of individuals, and the intersection of generations. The genetic algorithm is appropriate because of the examination of a set of possible responses, as well as less sensitivity to a particular form of optimum points for multi-objective optimization (Srinivas, 1994).

Based on the concept of Pareto dominance, first proposed by Vilfredo Pareto in 1986, we can define the optimality criterion in a multi-objective problem. For the first time Goldberg in 1989, using the Pareto optimization concept in a multi-objective genetic algorithm, proposed a method for sorting the undefeated responses. The multi-objective genetic algorithm proposed a method for sorting the undefeated responses. The genetic algorithm is the sorting of the undefeated responses of the genetic algorithm and reducing the computational time, increasing the efficiency, and also comparing the performance without the user's need for the benefit of this algorithm (Goldberg, 1989).

In solution with the method of the multi-objective genetic algorithm of undefeated sorting, the three concepts of dominance, sorting the undefeated responses, and maintaining the variety of the answers should be considered. These three concepts are called the multi-objective process of the solution.

In the concept of dominance this point is mentioned "in a minimization problem with more than one objective function, we say the X point dominates the Y point, if and only if Y is in no way better than X and X is strictly better than Y in one way". The points that have these conditions are considered as the first front. In the sense of sorting the undefeated answers, we must say that when we use a multi-objective algorithm for solving a problem, in most cases, points are found that none are superior to each other and cannot be compared two by two to the concept of overcoming. So they must be sorted according to a particular criterion in order to obtain the best solutions. In this algorithm, each answer is assigned a rank, which is based on the number of their defeats from other points. At the end of the algorithm, the points that have the best rank are chosen as the answer set or Parto front points. The concept of maintaining a

variety of answers also means that we sometimes have to compare and share some members of a total that have the same rank and eliminate some of them. This is done using the concept of maintaining the diversity of responses. The function of this stage, also known as the crowding distance is expressed mathematically.

$$d_i^1 = \frac{|f_1^{i+1} - f_1^{i-1}|}{f_1^{max} - f_1^{min}}$$

In this operator, each point that has a more crowding distance covers a larger area and its elimination causes the elimination of the diversity of responses in a large area. Thus, the points of the response set that have larger crowding distance must be eliminated in a extent that the primary population remains fixed. In addition, the primary and terminal points related to this set are important points that must surely exist among the responses and not be eliminated.

In this research, the number of population is 40 people and the repetitions are 100. In order to intersect and mutate we also must act as follow.

For intersection operator in the designed model in the algorithm, two methods are used and each one is selected randomly.

First method: single point method

Second method: two-point method

For mutation operator in the model, two methods are used and each one of them is selected randomly.

First method: Swap method. In this method, two values are selected and their situations are exchanged.

Second method: Reversion method. In this method, two values are selected and the situations of values are reversed.

Sorting the responses

After applying the operators of undefeated sorting and crowding distance, some responses are finally remained that primarily had high ranks and if they have equal ranks, they will have larger crowding distances.

Table 1- The values of Y_{ijt}

Y_{ijt}	Value			Y_{ijt}	value		
Y_{111}	1	1	1	Y_{211}	1	1	1
Y_{112}	1	1	1	Y_{212}	1	1	1
Y_{113}	1	1	1	Y_{213}	1	1	1
Y_{114}	1	1	1	Y_{214}	1	0	1
Y_{121}	1	1	1	Y_{221}	1	1	1
Y_{122}	1	1	1	Y_{222}	0	0	1
Y_{123}	1	1	1	Y_{223}	1	1	1
Y_{124}	1	1	1	Y_{224}	1	1	1
Y_{131}	1	0	0	Y_{231}	1	1	1
Y_{132}	1	1	0	Y_{232}	1	1	1
Y_{133}	1	1	0	Y_{233}	1	1	0
Y_{134}	1	1	0	Y_{234}	1	1	1
Y_{141}	0	1	0	Y_{241}	0	1	0
Y_{142}	0	1	0	Y_{242}	0	1	0
Y_{143}	0	1	0	Y_{243}	0	0	1
Y_{144}	1	0	0	Y_{244}	0	0	0

Table 2- The values of X_{ijt}

X_{ijt}	Sol1	Sol2	Sol3	Y_{ijt}	Sol1	Sol2	Sol3
X_{111}	51	19	41	X_{211}	40	52	21
X_{112}	35	10	57	X_{212}	30	51	32
X_{113}	34	19	41	X_{213}	22	9	24
X_{114}	28	38	52	X_{214}	33	0	42
X_{121}	23	48	37	X_{221}	93	104	88
X_{122}	20	38	22	X_{222}	110	89	103
X_{123}	28	39	30	X_{223}	84	79	120
X_{124}	36	25	34	X_{224}	101	104	90
X_{131}	5	0	0	X_{231}	25	0	49
X_{132}	23	25	0	X_{232}	0	24	43
X_{133}	5	8	0	X_{233}	36	53	0
X_{134}	10	20	0	X_{234}	38	51	20
X_{141}	0	10	0	X_{241}	0	0	0
X_{142}	0	8	0	X_{242}	0	9	0
X_{143}	0	4	0	X_{243}	0	0	3
X_{144}	12	0	0	X_{244}	0	0	0

Table 3- The optimal values of objective function

Objective functions	Objective function 1	Objective function 3
Solution1	10,980,120,000	10,889
Solution2	14,103,840,000	31,915
Solution3	13,292,465,000	48,923
Solution4	12,821,320,000	34,895
Solution5	10,920,100,000	20,903
Solution6	11,753,200,000	18,912
Solution7	13,222,170,000	02,884
Solution8	12,032,800,000	53,932
Solution9	12,504,210,000	97,901
Solution10	11,193,000,000	44,891

In order to study the validity and efficiency of the designed model of this research, particle swarm optimization algorithm is used.

III. PARTICLE SWARM OPTIMIZATION ALGORITHM

Particle swarm optimization algorithm has been originated from the motion of bird flocks and fishes. Particle swarm optimization algorithm is beyond a series of particles. None of particles can solve the problems by themselves and just when they have interaction, they can solve the problem. In fact for particle swarm optimization, problem solving is a social concept which is created by the behavior of each single particle and their interaction. However if the fitness function of the hypothesized problem is *f*, then in each stage, the values of x_i, v_i, y_i and $\hat{y}_i$ will be updated as below:

$$\begin{cases} v_{i,j}(t+1) = \omega(t)^* v_{i,j}(t) + r_{1,j}(t)^* c_1^* \left(y_{i,j}(t) - x_{i,j}(t) \right) \\ \qquad + r_{2,j}(t)^* c_2^* (\hat{y}_i(t) - x_{i,j}(t)) \\ \qquad x_{i,j}(t+1) = x_{i,j}(t) + v_{i,j}(t) \end{cases}$$

$$y_i(t+1) = \begin{cases} y_i(t) & \text{if } f(x_i(t+1) \geq f(y_i(t)) \\ x_i(t+1) & \text{if } f(x_i(t+1) < f(y_i(t)) \end{cases}$$

In the above equations, w is the inertia coefficient, $r_{1,j}$ and $r_{2,j}$ are uniform random numbers in (0 and 1) range and c_1 and c_2 are constant numbers which are referred to as acceleration coefficients and are called perceptual parameter and social parameters

in respect. c_1 is learning coefficient related to the personal experience of each particle while c_2 is learning coefficient for the entire community. r_1 and r_2 cause different types of answers and as a result more complete search is done on the space (Liao et al. 2011).

In each component the position and speed of birds are updated separately. To prevent from early convergence, extra increase in speed should be avoided. The most frequently used method is that at the time of updating the speed of each bird, a maximum is considered for the speed. If the speed is exceeded that amount, the following equation is used:

$$if \ v_{id} > v_{max} \ then \ v_{id} = v_{max}$$
$$else \ if \ v_{id} < -v_{max} \ then \ v_{id} = v_{max}$$

Inertial coefficient is not placed in the algorithm though it can be useful.

IV. THE RESULTS OF PARTICLE SWARM OPTIMIZATION

After running the algorithm, the results are interpreted in the following way:
-The matrices related to the allocated suppliers of each period are according to the following table:

Table 4- Values of Y_{ijt}

Y_{ijt}	Value			Y_{ijt}	value		
Y_{111}	1	1	1	Y_{211}	1	1	1
Y_{112}	1	1	1	Y_{212}	1	1	1
Y_{113}	1	1	1	Y_{213}	1	1	1
Y_{114}	1	1	1	Y_{214}	1	1	1
Y_{121}	1	1	1	Y_{221}	1	1	1
Y_{122}	1	1	1	Y_{222}	1	1	1
Y_{123}	1	1	1	Y_{223}	1	1	1
Y_{124}	1	1	1	Y_{224}	1	1	1
Y_{131}	1	1	1	Y_{231}	1	1	1
Y_{132}	1	1	1	Y_{232}	1	1	1
Y_{133}	1	1	1	Y_{233}	0	1	1
Y_{134}	1	0	1	Y_{234}	1	1	1
Y_{141}	0	1	1	Y_{241}	1	0	0
Y_{142}	0	0	1	Y_{242}	0	1	0

| Y_{143} | 1 | 0 | 1 | Y_{243} | 0 | 0 | 1 |
| Y_{144} | 1 | 1 | 0 | Y_{244} | 0 | 1 | 0 |

Table 5-Values of x_{ijt}

X_{ijt}	Sol1	Sol2	Sol3	Y_{ijt}	Sol1	Sol2	Sol3
X_{111}	48	53	29	X_{211}	42	14	32
X_{112}	53	71	65	X_{212}	40	31	20
X_{113}	38	40	52	X_{213}	28	53	27
X_{114}	31	44	38	X_{214}	38	40	11
X_{121}	32	27	27	X_{221}	73	85	101
X_{122}	21	12	18	X_{222}	88	105	93
X_{123}	23	32	21	X_{223}	115	74	83
X_{124}	23	32	30	X_{224}	78	68	92
X_{131}	20	10	18	X_{231}	11	22	8
X_{132}	10	5	7	X_{232}	21	10	33
X_{133}	18	8	12	X_{233}	0	9	18
X_{134}	11	0	14	X_{234}	39	21	30
X_{141}	0	2	1	X_{241}	2	0	0
X_{142}	0	0	3	X_{242}	0	12	0
X_{143}	2	0	3	X_{243}	0	0	4
X_{144}	17	7	0	X_{244}	0	10	0

Table 6- The optimal values of objective function

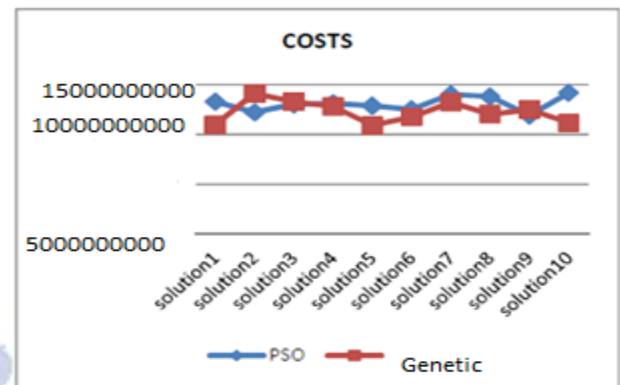| Objective functions	Objective function 1	Objective function 3
Solution1	13,292,380,000	12,911
Solution2	12,230,820,000	74,897
Solution3	13,032,250,000	99,852
Solution4	13,129,000,000	10,903
Solution5	12,890,100,000	69,883
Solution6	12,512,320,000	04,907
Solution7	14,021,910,000	71,881
Solution8	13,823,000,000	33,868
Solution9	11,903,300,000	36,910
Solution10	14,184,200,000	07,879

Figure 1- The comparison between Genetic and particle swarm optimization in the first objective function
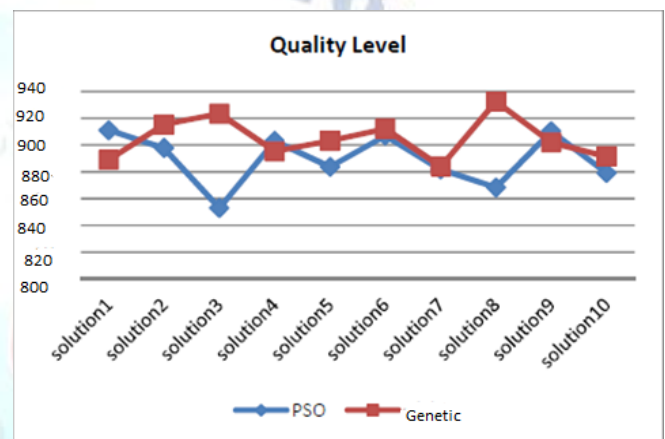

Figure 2- The comparison between Genetic and particle swarm optimization in the second objective function

V. CONCLUSION

Choosing an appropriate supplier and registering orders from each of them, are important elements which increase the efficiency and effectiveness of each supply chain and is included in a complex process which contains quantitative and qualitative criteria. The results of this research shows the reduction of costs in a way that in each order the company paid 10 percent more than the amount obtained from the model. The answers acquired by both methods are nearly close to each other. To execute this model, it is suggested that companies which are active in this field use the same model in order to determine the amount of orders received from each supplier.

REFERENCES

[1] Alem-e-Tabriz. A, Zandie. M, Rahimi. A.R and M, Ultra innovative algorithms in combined optimization, Eshraqi publication

[2] Burer, S., Jones, P.C., & Lowe, T.J. (2008). "Coordinating the supply chain in the agricultural seed industry", EuropeanJournal of Operational Research, 185(1), 354-377

[3] Stadtler, H., &Kilger, C. (2000). Supply chain management and advanced planning. Springe

[4] Shankar, B.L., Basavarajappa, S., Chen, J.C.H., &Kadadevaramath, R.S. (2013). "Location and allocation decisions for multi-echelon supply chain network – A multi-objective evolutionary approach". Expert Syestems with Applications, 40(2), 551-562

[5] Geringer, J. M. Joint venture partner selection: Strategies for developed countries. Westport: Quorum Books. 1988

[6] Garfamy, R. M, A data envelopment analysis approach based on total cost of ownership for supplier selection. Journal of Enterprise Information Management, 19(6), 2006, pp. 662-678

[7] Cebi F., Bayraktar D. "An integrated approach for supplier selection", Journal of Logistic Information Management, Vol. 16, No. 6, 2003, pp. 395- 400

[8] Xia W., Wu Z., Supplier Selection With Multiple Criteria in Volume Discount Environments, Omega. 2005

[9] Srinivas, N., Deb, K. ,"MultiobjectiveOptimizition using nondominated sorting in genetic algorithm", Evolutionary Computation, Wiley, New York, 1994

[10] Goldberg, D., "Genetic algorithm in search, optimizition and machine learning", Addison-Wesely. 1989

[11] Liao, C. J., Tseng, C. -T. and Luarn, P. "A discrete version of particle swarm optimization for flow shop scheduling problems", Computers & Operations Research, 84, 2011, pp. 8111–8000

[12] Aissaoui N, Haouari M, Hassini E. Supplier selection and order lot sizing modeling: A review. Computers & Operations Research 34, 2007, pp. 3516- 3540