

TO DEVELOP AN INTEGRATED MODEL FOR GREEN SUPPLY CHAIN

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ABSTRACT

Supply chain management is a set of techniques used for effective and efficient integration of suppliers, manufacturers, warehouses and dealers in such a way that system costs to be minimized and goods service needs to be realized with the correct number in the right place and at the right time. Since the important role of three factors of localization, routing and assignment is not covered in the survival of a supply chain life, therefore, integration of these factors will result in an effective supply chain. This research aims to study the issue of supply chain network design including the localization of facilities, allocation flow among facilities and routing decisions. The issue is to determine the number, location and capacity levels of distribution centers, to allocate customers to distribution centers and distribution centers to suppliers and routing decisions such as determination of the products transport route from distributors to customers and type of transport vehicles so that the total cost of the system to be minimized and customer coverage to be maximized. In addition to reducing costs and increasing quality, improving the environmental performance of the supply chain and decreasing the costs of environmental degradation is also included in the proposed issue. This necessity which is known as a green supply chain is observed by choosing vehicles with lower emissions and reducing transport distances.

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On the other hand, this research role includes the impact of sharing information through raising and reducing waiting times for carriers. All of the above will be formulated by an integer linear programming model. Given that the mentioned issue is located in the group of problems with hard complexity, this article suggests using multi-objective meta-heuristic algorithms for optimization of the problem and compares the efficiency of the proposed algorithms with each other using several random sample problems.

Keywords: Localization, routing, allocation, green supply chain, sharing information.

1. INTRODUCTION

Supply chain encompasses all the processes that link supplier firms to customers. These processes start from raw materials and end to the final consumer who receives the completed product. More precisely, the chain management involves all processes of materials from purchasing, internal controls, materials planning for production, inflow inventory control and warehouses, transportation and distribution of the final product. It also includes physical distribution and logistical support of all foreign logistic activities in order to service the customer. These activities contain taking orders, inventory establishment, warehousing, localization, external transport, pricing, advertising and product placement and life cycle support. Due to the combination of materials management actions and physical distribution and logistics, a supply chain can't be simply linear chains of commercial one to one communications but it is a tissue of multiple communications and networks.

Since supply chain management is based on an efficient integration of suppliers, manufacturers, warehouses and stores, supply chain management includes all the activities of firms from strategic to tactical and operational levels. Supply chain design should be done in such a way that it can cover all these activities. In order to design a supply chain it is essential to decide in five areas: production, inventory, localization of products, transportation and information (Chopra et al, 1998). These five areas are considered as operating leverages. By managing these leverages, capabilities required to a supply chain could be created. Efficient management of the supply chain needs to understand any leverage and how it functions. Each of these leverages makes a direct impact on the supply chain and enables specific capabilities in the chain. The correct combination of responsiveness and efficiency of these leverages simultaneously, leads to the increased efficiency with reduced inventory and operating costs in the supply chain.

On the other hand, in recent years, environmental pollution has become a challenging issue for commercial organizations. Business operations such as sourcing and manufacturing are known as the main factors in this field. The operation has increased pressure to reduce the environmental pollution. Green supply chain management leads to organization's achievement to profitability and market share by reducing the risks and environmental impacts while its ecology efficiency is increased. In general, the creation of green supply chain and consideration of ecological problems reduce the costs, improve environmental performance and increase reputation of the company.

In this paper, by considering effective factors of the chain we try to develop a comprehensive and integrated mathematical model. Among the difficulty causes in integrating the different members of the chain, conflicting goals among members can be noted. Therefore, the developed model is placed in the multi-objective problems group. This model includes ability to optimize the localizing and routing problem with the approach of creating a green chain involving costs of construction and commissioning cross warehouses, different levels of information sharing, the maximum population coverage in service and reduction of transportation costs. The rest of this article is organized as follows:

Literature of supply chain management, classic localization problems, vehicle navigation and location-routing problem background are presented in the second section. Section 3 provides the proposed mathematical planning model for the problem regarding levels of information sharing and environmental pollution. Section 4 describes the proposed solution for solving the model. Section 5 presents analysis of the solution results and finally section 6 provides conclusion and suggestions for future studies in the field of the research.

2. REVIEW OF LITERATURE

To minimize the total cost is the most common objective in routing-location problems which includes storage and transport costs. A limited number of studies in this area have chosen another objective function or functions with multi objectives. Studies conducted by Averbakh and Berman (1995) Averbakh and Berman (2002), Jamil and Batta(1994), Averbakh et al (1994) and Aksent and Altinkerner(2008) are some studies of this area. Localization as the maximum coverage with the aim of minimizing the costs of constructing service centers are first introduced in 1974. Then, significant improvements have been made due to the various studies in this area.

To minimize the transfer of harmful material costs, fixed costs of facilities and the risk of exposure to harmful substances discovery were considered as objective functions in a research conducted by Kara and Alumur (2007). Ghiani and Laporte (1999) examined a structure in which vehicles start the rout from the warehouse, move between different vertices (customers), deliver products to the customers and return to the warehouse after completion of the inventory. Instead of vertices, vehicles may go through edges between the vertices. This case is known as the routing.

Ahn and Ramakrishna (2002) suggested application of genetic algorithms to solve the shortest path problem. Through the computerized simulation, they showed that in terms of convergence the proposed algorithms act better than other traditional algorithms. Wu et al(2002) considered warehouses location and the number of available trucks without restriction. For this purpose, they introduced an innovative model which simply involved public costs of transport issue. Jensen and Barahona (1998) presented a model for determination of warehouses location and customers' allocation. This model in addition to the consideration of maintenance costs in stock included limitations on the level of service. Through this problem which was associated with designing of computer spare parts distribution network, at least 95% of demand should have responded in less than two hours. According to Chen et al (2007), in order to determine the minimum cost of moving, a number of vehicles which begin to move simultaneously from the warehouse and after meeting customers provided that first each node is only met by one of the vehicles and second each vehicle doesn't load more than its capacity during the rout and then come back to the warehouse under the title of genetic effective combined algorithm can be used for solving the vehicle routing problem.

Ahn and Ramakrishna (2002) in their study considered objective functions as minimizing the transfer of harmful material costs, fixed costs of facilities and the risk of exposure to harmful substances discovery. Barreto et al, (2007) applied an innovative method based on customers' classification for solving location-routing. They used a number of hierarchical and non-hierarchical methods for the classification. Emerson et al, (2009) focused on information sharing in a dynamic supply chain. They found that players in the supply chain can update the relevant knowledge independently at the time of notifying partners. They used a knowledge based framework to analyze the effects of inventory constraints on the mobility of supply chains performance. They showed that none of the static and dynamic configurations is consistently

dominant. They also showed that the dynamic selection of a supplier or assembler doesn't ever optimize interests and profits but by selecting an appropriate supplier can be beneficial.

Yu et al (2010) employed initiative simulated annealing algorithm for solving location-routing problem. They used three neighborhood structures for improving the performance of simulated annealing algorithm. They claimed that using these structures improve the simulated annealing algorithm to solve location-routing problem. They applied three neighborhood structures with possible selection to improve the performance of simulated annealing algorithm. By presenting a non-linear mixed model, Yu et al (2010), combined problems of localization, allocation and inventory. Ahmadi and Azad (2010) developed a unified model for designing distribution networks in prospective mode which involved decisions of localizing, inventory and routing, simultaneously.

Shin et al (2011) worked on timely delivery so that construction of a framework facilitates gathering and sharing information in construction components and the flow of materials throughout the entire process of the chain. Therefore, the present research aims to develop an integrated information management framework that could provide logistical information for those involved with the project and their decision making. Pilot testing of the framework developed in this research showed that this framework can improve the effectiveness by about 32% compared to the traditional supply chain management. Duroc and Kaddour (2012) investigated the impact of information sharing technology on green projects leading to the achievement of efficient energy production chain, better control of waste, recycling and other environmental challenges. Ahmadi Javid and Sediqi (2012) re-investigated localization-inventory- routing by applying changes in the assumptions. Chen et al, (2013) used purring and sharing information in supply chain management and studied three separate rows of inefficient transport, storage and retrieval of operations. Their preliminary experiments showed that operations total time can be stored by 81% from the current to the next phase. This figure can be reached to 89% by integrating information sharing and purring. Glock and Kim (2014) studied closed-loop supply chain to transfer goods from suppliers to retailers and investigated the case where to return a part of products to the supplier is random through which the product location can be tracked and supported by sharing the information. Santoso et al (2015) studied localizing of wind turbines and routing machines repairing turbines. They also analyzed the impact of repairing machines first place. According to the results, the correct choice of repairing machines

path and their first place may have a substantial impact on the timely maintenance and repair of turbines.

Tofighi et al (2016) presented a possible model for dihedral supply chain. They used a two-stage innovative approach to solve the model. In this approach, warehouse location and capacity levels were determined at the first stage and the transport of goods between warehouses and the customer was determined at the second stage. Computing results demonstrated the efficacy of this approach in the optimization of the suggested model.

As noted, none of the researches have simultaneously addressed localizing, assigning and routing in a green supply chain. Hence, this study offers a comprehensive model that is able to make optimal decision by considering many parameters affecting the chain. On the other hand, the proposed model takes into account the impact of sharing information through reducing the waiting time, too.

3. PROBLEM DESCRIPTION AND MODELING

This paper studies the location-routing problem in a two echelon supply chain. This chain is composed of several factories producing several products, many distribution centers (temporary storage) and customers of the chain. The distribution network structure of this scenario is as follows:

The first level consists of several factories or supplier that each one offers different products. Factories location is predetermined. At this level, except for the cost of transportation from factory to warehouse, no other fees will be considered.

The second level consists of warehouses or potential distribution centers with a specific capacity that is solely intended for temporary storage of the products.

The third level consists of the final consumers. To allocate and distribute the products from warehouses to the customers, carrying starts from the warehouse and moves through the vertices dedicated to the warehouse and returns to the primary storage after completing products. Other assumptions considered in a given supply chain are as follows:

- Location of warehouses contains a specified number of predetermined points and is fixed as establishment costs.
- Each customer's demand is definitive and predetermined.
- The distance between the supplier, warehouses and customers is fixed and specified

- Carrying vehicle capacity is definitive and different per various products.

To model the above problem at first we define the following indices and parameters.

Indices set

I Potential warehouses set ($i= 1 \dots m$)

J customers set ($j= 1 \dots n$)

V transportation machinery set ($v= 1 \dots p$)

P products set ($p=1 \dots q$)

N_i Possible levels set for creating warehouse in the node i

S levels for sharing the information ($s=1 \dots s$)

Parameters of the problem

CAP_i^{np} Capacity of warehouse i made in level n for the product p

Q_v^p Capacity of vehicle v for the product p

$demand_j^p$ Demand of the customer j for the product p

$COST_i^n$ Cost of constructing a warehouse at the level n in the node i

B Funds available to build warehouses

CO_v Pollution rate produced by the vehicle v per unit of meter

$prod^p$ Production rate of the product p

$d_{i,j}$ The distance between the nodes i and j

$d'_{i,p}$ The distance from the node i to the production place of the product p

c_v Operating costs of the vehicle v per unit

$t_{i,v}^p$ Transfer time of the product p to the warehouse i by vehicle v

wt_i Expected cost of storage per unit of time

$MAXT_i^p$ The maximum time allowed for coming the product p to the warehouse i

LT_s^p Vehicles waiting time to receive the product p if information is shared in level s

IC_s^p Cost to share information in level s for product p

Decision variables

$X_{i,j,v}^p$ 1 If the node i is placed before the node j in the path of the vehicle v carrying the product p
0 otherwise

Y_i^n 1 If a warehouse with capacity level of n is built in the place of the node i
0 otherwise

$Z_{i,j}^p$ 1 If the customer j receives the product p from the warehouse i
0 otherwise

$H_{i,v}^p$ 1 If the product p is transferred to the warehouse i by the vehicle v
0 otherwise

IS_s^p 1 If the information for the product p is shared in the level s
0 otherwise

$M_{i,v}^p$ The auxiliary variable of removal restriction of Subtour on the v vehicle path carrying the product p

The mathematical expression of the objective functions and constraints in the problem are as follows.

(1)	$\min OF_1 = \sum_{i \in I} \sum_{v \in V} \sum_{p \in P} H_{i,v}^p \times c_v \times d'_{i,p} + \sum_{i \in (I \cup J)} \sum_{j \in (I \cup J)} \sum_{v \in V} \sum_{p \in P} X_{i,j,v}^p \times c_v \times d_{i,j} + \sum_{n \in N_i} \sum_{i \in I} Y_i^n \text{COST}_i^n + \sum_{p \in P} \sum_{s \in S} IS_s^p IC_s^p$	
(2)	$\max OF_2 = \sum_{i \in I} \sum_{j \in J} \sum_{p \in P} Z_{i,j}^p \times \text{demand}_j^p$	
(3)	$\min OF_3 = \sum_{i \in I} \sum_{v \in V} \sum_{p \in P} H_{i,v}^p d'_{i,p} CO_v$	
(4)	$\forall j \in J, p \in P$	$\sum_{i \in (I \cup J)} \sum_{v \in V} X_{i,j,v}^p \leq 1$
(5)	$\forall j \in I \cup J, v \in V, p \in P$	$\sum_{i \in (I \cup J)} X_{i,j,v}^p - \sum_{i \in (I \cup J)} X_{j,i,v}^p = 0$
(6)	$\forall v \in V, p \in P$	$\sum_{i \in I} \sum_{j \in (I \cup J)} X_{i,j,v}^p \leq 1$
(7)	$\forall i \in I, p \in P$	$\sum_{v \in V} H_{i,v}^p \times Q_v^p \leq \sum_{n \in N_i} CAP_i^{np} \times Y_i^n$
(8)	$\forall v \in V, p \in P$	$\sum_{i \in (I \cup J)} \sum_{j \in J} X_{i,j,v}^p \times \text{demand}_j^p \leq Q_v^p$
(9)	$\forall i \in I, p \in P$	$\sum_{j \in J} Z_{i,j}^p \times \text{demand}_j^p \leq \sum_{v \in V} H_{i,v}^p \times Q_v^p$
(10)	$\forall i \in I, j \in J, v \in V, p \in P$	$\sum_{u \in (I \cup J)} X_{i,u,v}^p + \sum_{u \in (I \cup J)} X_{u,j,v}^p - Z_{i,j}^p \leq 1$

(11)	$\forall i \in I$	$\sum_{n \in N_i} Y_i^n \leq 1$
(12)		$\sum_{n \in N_i} \sum_{i \in I} Y_i^n \text{COST}_i^n \leq B$
(13)	$\forall p \in P$	$\sum_{i \in I} \sum_{v \in V} H_{i,v}^p \times Q_v^p \leq \text{prod}^p$
(14)	$\forall i \in I, p \in P$	$\sum_{v \in V} H_{i,v}^p t_{i,v}^p + \sum_{s \in S} IS_s^p LT_s^p \leq \text{MAX}T_i^p$
(15)	$\forall p \in P$	$\sum_{s \in S} IS_s^p = 1$
(16)	$j \in J, p \in P$	$\sum_{i \in I} Z_{i,j}^p \leq 1$
(17)	$i \in I, p \in P$	$\sum_{v \in V} H_{i,v}^p \leq 1$
(18)	$\forall i, j \in J, v \in V, p \in P$	$M_{i,v}^p - M_{j,v}^p + NX_{i,j,v}^p \leq N - 1$
(19)	$\forall i \in (I \cup J), j \in (I \cup J), p \in P, v \in V$	$X_{i,j,v}^p \in \{0,1\}$
(20)	$\forall i \in I, n \in N_i$	$Y_i^n \in \{0,1\}$
(21)	$\forall i \in I, j \in J, p \in P$	$Z_{i,j}^p \in \{0,1\}$
(22)	$\forall i \in I, v \in V, p \in P$	$H_{i,v}^p \in \{0,1\}$

First objective function (1) consists of four parts. The first part is trying to minimize shipping costs from the supplier to warehouses. The second part minimizes shipping costs from the warehouse to the customer. The third part is trying to minimize the total cost of warehouses construction. Part 4 is trying to minimize costs of sharing information. The second objective function (2) maximizes the coverage level of the customers. The objective function (2) can be viewed as the serviceability of the system. The third objective function (3) minimizes the total pollution generated due to the transfer of goods to the warehouses. Limitation set (4) ensures that each customer should be serviced once at most per product. Limitations set (5) ensures that if a vehicle arrives a node, make sure it comes out. Limitation set (6) ensures that a vehicle starts the motion just from one warehouse. According to limitations (5) that establish the balance in entry and exit nodes and according to the limitations (6) it can be concluded that each vehicle starts the rout from the warehouse and completes it there. Limitation set (7) ensures that the entrance rate to the warehouse doesn't exceed the capacity. Limitations set (8) ensures that the input rate of each product to each vehicle is less than or equal to its capacity. Limitation set (9) is a control restriction which controls input rate of any product to the warehouse or the output rate from there. Limitation set (10) establishes the relationship between assigning and routing in the model: Customer i is assigned to the warehouse i if only the vehicle v which passes the customer i node, will start the tour from the warehouse i . Limitations set (11) ensures that any stock can be created only in one capacity level. Limitation set (12) controls the total budget. Limitation set (13) ensures that the shipped product p to the warehouses does not exceed the production rate. Limitation set (14) controls arrival time of the product to the warehouse. Limitation set (15) ensures that any product information is shared at least at one level. Limitation set (18) prevents creating sub-tour. Limitation sets (19) to (22) control the variable values.

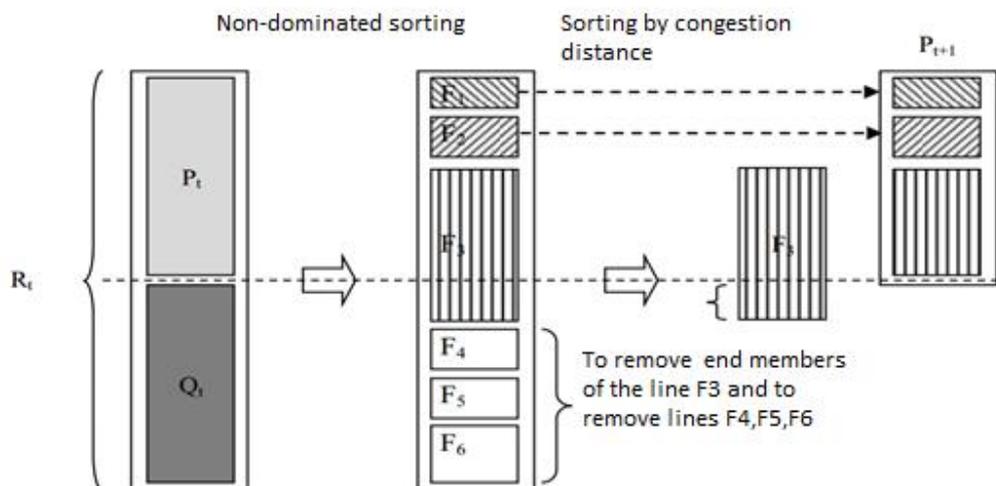
4. OPTIMIZATION ALGORITHMS

The current research uses two meta-heuristic multi-objective algorithms to solve the presented model. These algorithms include: Non-dominated sorting genetic algorithms and non-dominated ranked genetic algorithm. To use these algorithms or any other meta-heuristic in a multi-objective context we need to make some changes in algorithms and adapt response- operators structure in such a way that to involve goals and restrictions of the studied problem. Thus,

outlines of the proposed algorithms and the structure of response- operator definition are going to be explained in the next section.

4.1 Non-dominated sorting genetic algorithms (NSGA-II)

This algorithm was proposed by Deb et al. and to have a clear approach for providing density among the Pareto optimal answers is the main advantage of the algorithm (Deb, 2001). In this method, initially the children population (Q_t) is made using the parental population (P_t). After merging populations, non-dominated sorting is used to categorize all members of the population. The categorization is indicated by lines F_1, F_2, \dots, F_n . F_1 queue members are those who have overcome other lines members and the last line members are those who have been defeated in competition with members of other lines. Now, to generate a new population (P_{t+1}), the first lines are placed in the population P_{t+1} . When the number of the new population reaches to N , the process of placing lines members in the new population is stopped. If there is a line that by placing it in the new population the population members will reach to a number more than N , members of the line will be ranked by congestion distance; moreover, in order to be placed in the new population members with a more congestion distance will be prioritized (Dep, 2001).



4.2 Non-dominated ranked genetic algorithms (NRGA)

Although many problems have been well resolved via multi-objective evolutionary algorithms, the researchers try to introduce better operators for these algorithms to increase the efficiency.

Among these operators, the main focus has been on improving multi-objective evolutionary algorithms.

A new multi-objective evolutionary algorithm based on population called as genetic algorithm based on ranking non-dominants was successfully developed by Al Jadaan et al in 2008 to optimize non-convex, non-linear and discrete functions. They studied multi-objective algorithms which operated based on ranking non-dominants. According to the current problems in previous approaches, they developed a new approach by combining roulette wheel selection algorithm based on the rating and population ranking algorithm on the basis of Pareto that was named as non-dominated ranked genetic algorithms (NRGA).

4.3 Answer structure (chromosomes)

Presentation of the answers is examined in this section. To present answers at first one chromosome changes to a p-dimensional structure that p represents the number of products. Each dimension of p creates a matrix. The number of rows and columns of the matrix is variable. The first column indicates the vehicles to transport the goods to the warehouse and the second column represents the vehicles to transport goods from the warehouse to customers. The third column specifies the warehouse and the fourth to the end columns reflects the customers.

Recommended chromosome is made based on the following steps.

- 1) Consider the product number p.
- 2) At first the customers who are going to receive the product p are selected randomly.
- 3) Then, a number of failure points are created among the customers and they are divided into some specific groups.
- 4) Warehouses are selected according to the number of groups. The assigned vehicle is selected in such way that its capacity would not be less than the total demand of the target group.
- 5) A number of vehicles are assigned to each warehouse to carry the product p to the warehouse. Vehicles are selected in such a way that the total capacity will be more than the associated customers' demand.
- 6) Repeat steps 1 to 5 for all products.
- 7) Total demands entering into each warehouse are calculated and the warehouse capacity will be determined.

First dimension (p=1)	First dimension (p=2)
The first product movement pattern	The second product movement pattern

Information level	customer					warehouse	vehicle	
1	9	7	5	1	8	1	11	[2,6]
			4	3	2	2	10	[5,8]

Information level	customer			Warehouse	vehicle
3	7	5	3	2	[1,2,4]

Fig.2. Presentation of answer structure (chromosomes)

Figure 2 shows the chromosome where there are 2 products, 8 potential warehouses, 12 potential vehicles and 9 customers. The chromosome shows that customers 8, 1, 5, 7, 9, 2, 3 and 4 have received the product 1. This means that at first vehicles 2 and 6 have carried the product 1 to the warehouse 1 and carried it from the warehouse 1 to customers 8, 1, 5, 7 and 9, respectively. Moreover, the vehicles 5 and 8 have carried the product 1 to the warehouse 2; the vehicle 10 has transferred the product 1 from the warehouse 2 to customers 2, 3 and 4, respectively. And so forth for the second product. In addition, the first product information is shared in level 1 and the second product information is shared in level 3.

Designed chromosomes include all decision variables. For example the genes associated with the first dimension shows that for the first product, customers 8, 1, 5, 7, 9, 2, 3 and 4 have been assigned to the warehouse 1 that is the same as variable $Z_{i,j}^p$ and Y_i^n . Also, the first product is carried from the warehouse via the vehicle 11 and its pass way is as follows, respectively: from the warehouse 1 to the customer 8, from the customer 8 to the customer 1, from the customer 1 to the customer 5, from the customer 5 to the customer 7, from the customer 7 to the customer 9

and finally from the customer 9 to the warehouse 1. This process shows the decision variable $X_{i,j,v}^p$. The decision variable $H_{i,v}^p$ is located in the first column that means the product 1 has been carried to the warehouse 1 by the vehicle 6.

4.4 Crossover operator

Crossover operator is the main strategy for generating new chromosomes in genetic algorithm. The use of an appropriate operator so that doesn't remove the answer out of the justified state is a noticeable point. In this study to do the crossover operation the below steps are followed (figure 3):

- 1) Two chromosomes are selected from the population considering the selection strategy.
- 2) Make a random number between one and p; p represents the number of products and r is called as the cross point
- 3) Now, the selected chromosomes are randomly paired with eachother.
- 4) Bits 1 to cross point in the first parent chromosome gene are directly copied into the first child's genes.
- 5) Bits cross point + 1 to N of the second parent are transferred to the first child according to placement of bits in the second parent.
- 6) The above steps repeat to produce other chromosomes of the child.

Child 1		
First dimension (p=1)	Second dimension (p=2)	second dimension (p=3)
The first product movement pattern	The second product movement pattern	The third product movement pattern

Child 2		
First dimension (p=1)	Second dimension (p=2)	Second dimension (p=3)
The first product movement pattern	The second product movement pattern	The third product movement pattern



Child 1		
First dimension (p=1)	Second dimension (p=2)	Second dimension (p=3)
The first product movement pattern	The second product movement pattern	The third product movement pattern

Child 2		
First dimension (p=1)	Second dimension (p=2)	Second dimension (p=3)
The first product movement pattern	The second product movement pattern	The third product movement pattern

Fig.3. Cross operator

4.5 Mutation operator

The main task of mutation operator is to avoid the convergence and local optimum and to search in untouched spaces of the problem. Chromosome mutation means its genes change and dependent on the type of coding has different methods. To apply mutation on chromosomes, the below steps are followed (Figure 4):

- 1) One chromosome is selected from the population.
- 2) The chromosome is mutated so that genes of a certain product are chosen from the chromosome and are arranged in reverse at all rows.

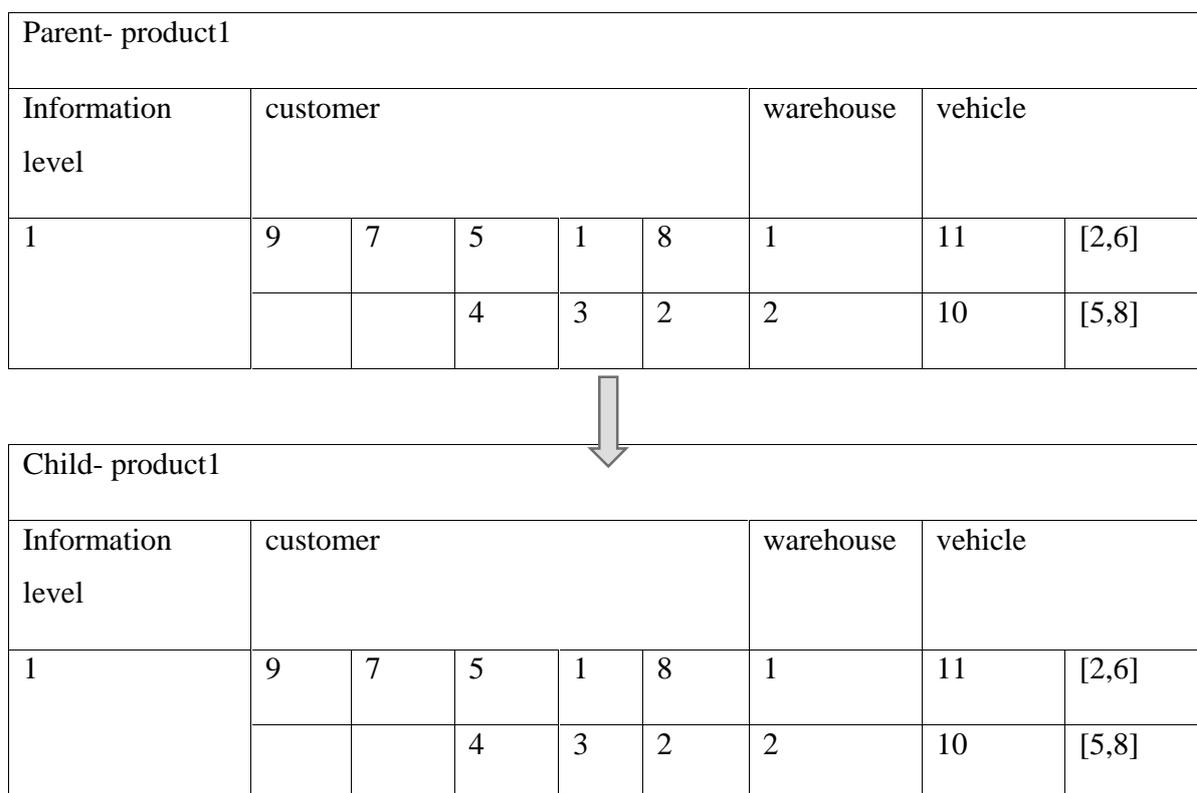


Fig.4. Mutation operator

It should be mentioned that the applied mutation operator still keeps the justified chromosome as valid.

4.6 Stop criteria

The last step in genetic algorithms is to study the stop conditions. In this regard, there is not a standard technique for stop conditions of multi-objective optimization algorithms. Therefore, in this study the algorithm stops when it reaches a predefined maximum repetition. The number of repetitions in the parameter adjustment will be calculated with the help of Taguchi tests.

5. COMPUTATIONAL RESULTS

Following assessments and description of the proposed mathematical model structure, non-dominated sorting genetic algorithms (NSGA-II) and non-dominated ranked genetic algorithms, in this section effectiveness of the proposed algorithms is evaluated using the sample problems and computational results analysis. Since benchmark problems do not exist in the literature, a number of sample problems were randomly generated. Generated problems are located in 6 different classes due to the number of customers, products and warehouses. The first category

includes problems with the 5 warehouses, 8 customers and 5 products; the second class has 5 warehouse, 10 customers and 5 products; the third group includes problems with the 5 warehouses, 15 customers and 10 products, the fourth group includes problems with the 5 warehouses, 20 customers and 10 products; the fifth category has problems with 10 warehouses, 40 customers and 5 products and the last category includes problems with 10 warehouses, 50 customers and 10 products. In each group, 5 random problems are generated and used to evaluate the performance of algorithms. First, to set these algorithms the parameters are done for operation in the best conditions and optimal values of algorithms parameters are determined. Parameters values are examined at three different levels and ultimately the optimal level of each parameter is determined using the Taguchi method. Table (1) displays the parameters, levels and optimum values.

Table 1. Optimal values of parameters

algorithms	parameters	description	Level	Level	Level	Optimal
			1	2	3	value
NSGA-II	$nPop$	Initial pop size	100	200	300	200
	P_c	Percent of cross over	0.75	0.85	0.95	0.85
	P_m	Percent of mutation	0.1	0.15	0.2	0.1
	<i>Iteration</i>	Number of generation	100	225	400	400
NRGA	$nPop$	Initial pop size	100	350	500	350
	P_c	Percent of cross over	0.7	0.8	0.9	0.7
	P_m	Percent of mutation	0.1	0.2	0.3	0.1
	<i>Iteration</i>	Number of generation	200	400	600	400

5.1 Assessment indicators of multi-objective algorithms performance

As mentioned, the proposed multi-objective algorithms operate and explore based on Pareto. Moreover, as we know the final discovered Pareto via algorithms should contain two features of good convergence and diversification. For this purpose, it is necessary to examine various measures to ensure a comprehensive understanding of the performance of a multi-objective algorithm. In this research, spacing indicators, the most extension (Diversity), the number of solutions in Pareto (NOS) and computational time (Time) are considered to measure algorithms effectiveness.

Figure 5 shows algorithms efficiency in the most extension index. In the most extension index any of algorithms are not preferred obviously relative to each other. Figure 6 shows algorithms efficiency in the Pareto index answers number. Since as the Pareto answers number is more it will be better, so we can conclude that NSGA-II algorithm acts better than NREGA algorithm and can find more answers in Pareto's first line. Figure (7) displays algorithms efficiency in the spacing index. In the spacing index and small size problems none of the algorithms is preferred relative to each other. However, by increasing the problem size, the better performance of the algorithm NREGA than NSGA-II is revealed. Figure (8) shows superiority of the algorithm NREGA to NSGA-II over the run time. According to this figure, the algorithm NREGA performs similar to the algorithm NREGA-II in small size problems; however, performance of the algorithm NREGA is improved by increasing the problem size so that makes a significant difference with the algorithm NSGA-II.

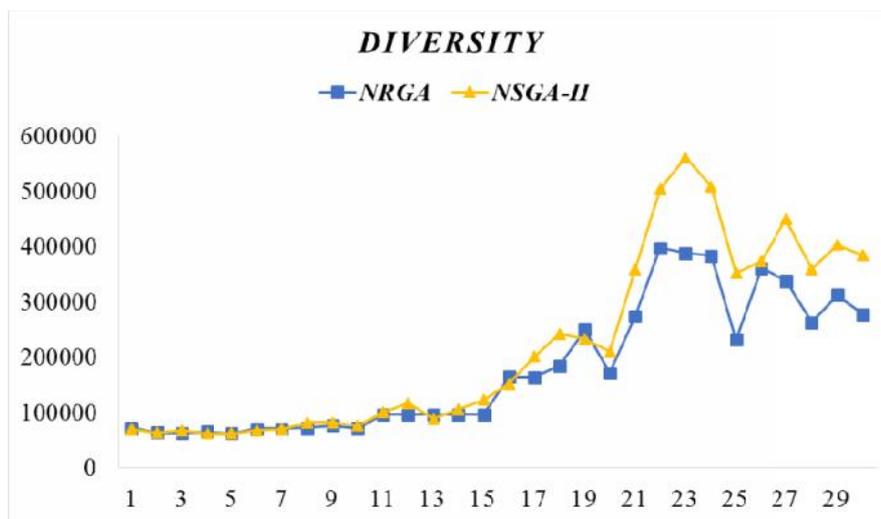


Fig.5. The proposed algorithms results chart for the most extension criterion

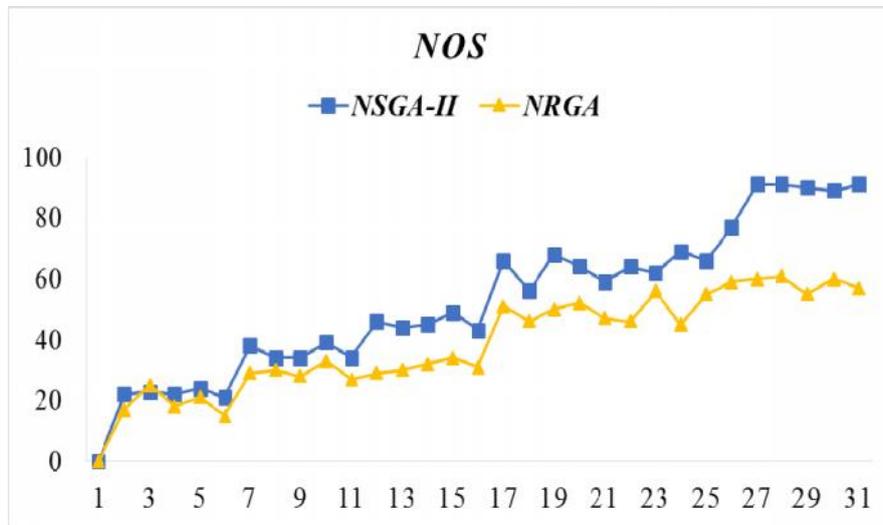


Fig.6. The proposed algorithms results chart for Pareto answers number criterion

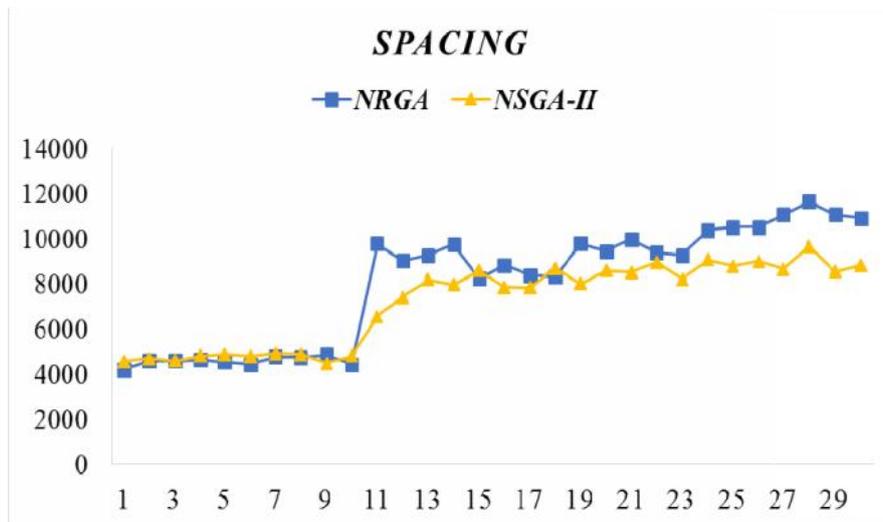


Fig.7. The proposed algorithms results chart for the spacing criterion

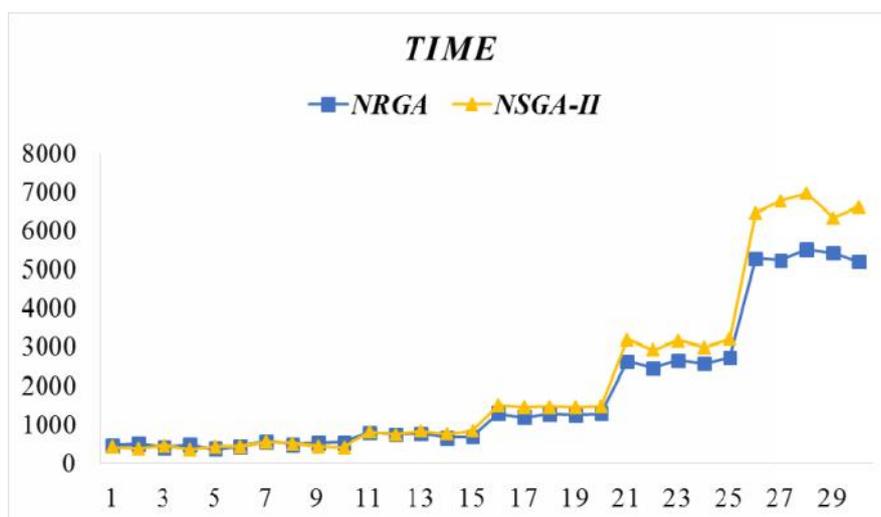


Fig.8. The proposed algorithms results chart for the computational criterion

To evaluate the quality of the proposed algorithms we used comparison indices. In general, superiority of algorithms can't be specified by the average of comparison indices. To specify algorithms with high performance we use statistical analysis techniques. For this purpose, a confidence interval of 95% is drawn. According to the figures (9) and (10) we can say that in most extension and Pareto answers number criteria, NSGA-II is more efficient than NPGA. Also, according to the figure (11) NSGA-II has similar performance compared to NPGA in the spacing criterion. Based on the figure (12), it can be concluded that the calculation time of algorithm NSGA-II is more than NPGA and NPGA is more efficient in this criterion.

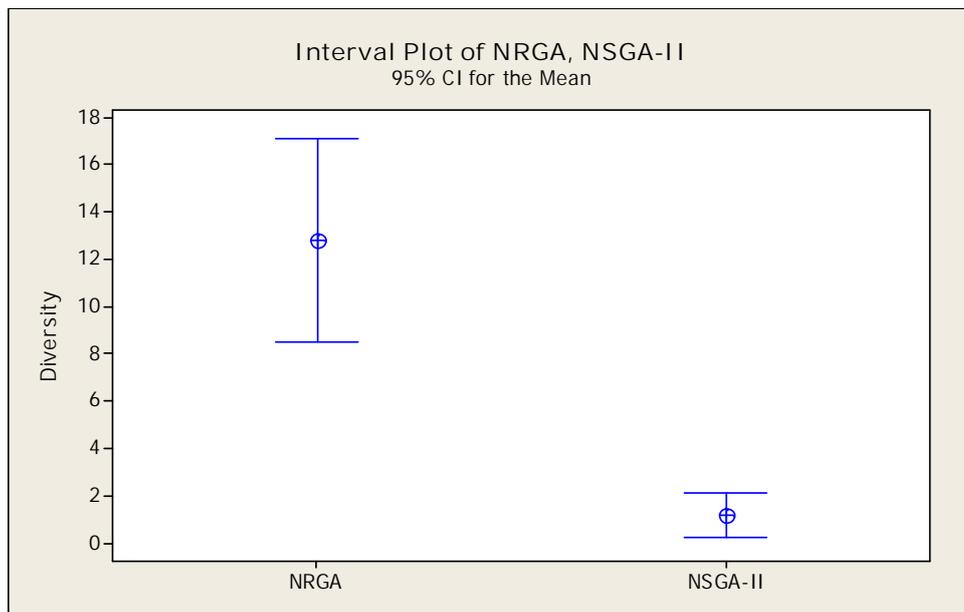


Fig.9. Confidence interval of 95% for the most extension criterion in the proposed algorithms

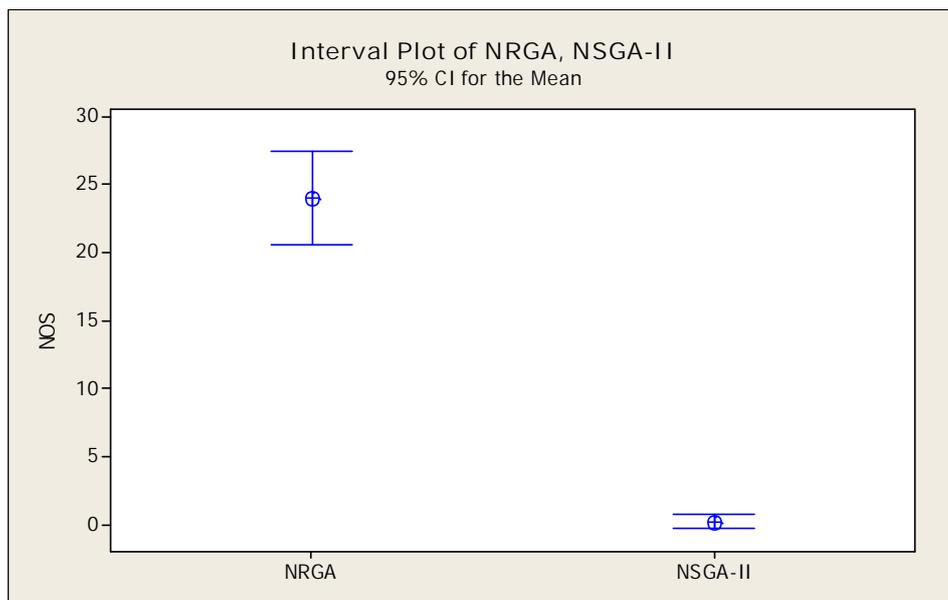


Fig.10. Confidence interval of 95% for the Pareto answers number criterion in the proposed algorithms

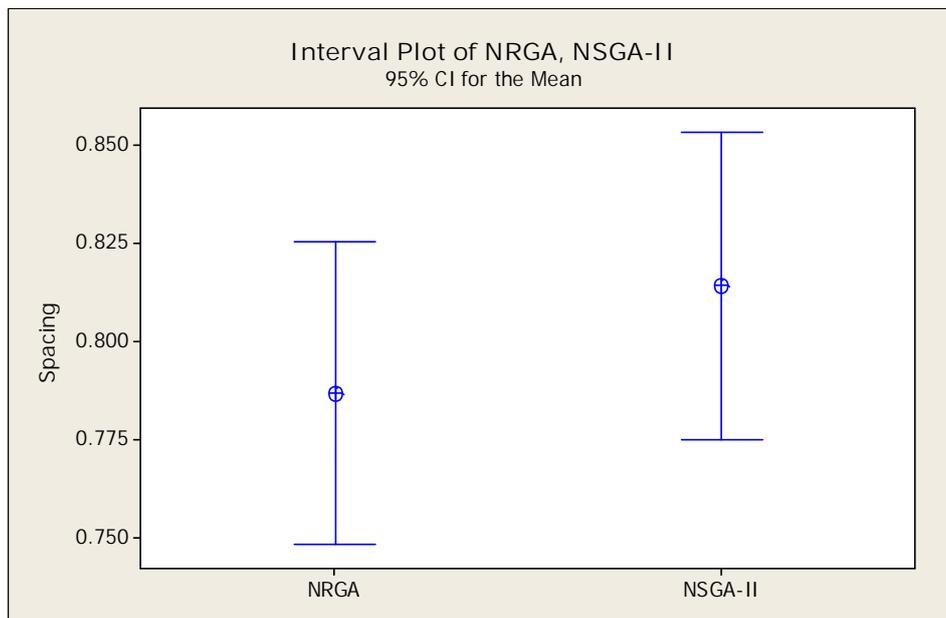


Fig.11. Confidence interval of 95% for the spacing criterion in the proposed algorithms

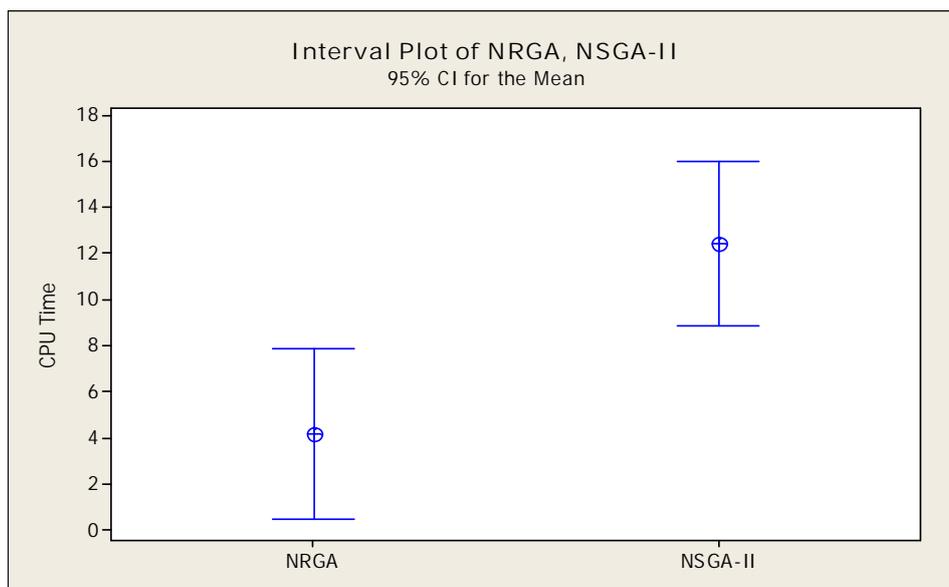


Fig.12. Confidence interval of 95% for the computational time criterion in the proposed algorithms

6. CONCLUSIONS AND SUGGESTIONS

In this research we tried to make the model more practical by developing localization-assignment problem as a category of combined models in the field of supply change and adding objectives related to the green supply chain. The presented model is to minimize total costs of

the supply chain as well as to maximize customers' satisfied demands and to minimize the pollution rate produced by transportation. According to the research literature, mixed problems of the supply chain and since the proposed model is three-objective, nonlinear and integer, this model is located among the difficult problems and innovative and meta-heuristic methods should be used to solve it. In order to optimize the model, Non-dominated Sorting Genetic Algorithm (NSGA-II) and Non-dominated Ranked Genetic Algorithm (NRGA) was used. To increase efficiency of the algorithms used in this study, the input parameters have been set at the best level through the Taguchi method. Finally, the solution algorithms were implemented on numerical problems with different sizes and the efficiency and the obtained answers quality were evaluated. In total, according to the defined criteria and statistical survey, meta-heuristic algorithm NSGA-II performs better than the algorithm NRGA. To develop the issues presented in this paper the following studies are suggested:

1. To develop the problem through applying changes on assumptions: For example, to consider discount in an exponential form, to consider back rent state, to consider vehicles destruction and etc.
2. To develop the problem through presenting better methods: Given that the algorithm NSGA-II defeated NRGA, to develop and offer another algorithm for solving the problem can be employed.
3. To increase adaptability of the proposed model, simulation can be added to the model.

7. REFERENCES

1. Ahn, C. W., Ramakrishna, R. S. A geneticalgorithm for shortest path routing problem andthe sizing of populations. *IEEE Transaction on EvolutionaryComputation*. 2002, 6 : 566-579.
2. Aksen, D., Altinkemer, K. A location-routing problem for the conversion to the “click-and-mortar” retailing: The static case. *European Journal of Operational Research*. 2008, 186 :. 554-575.
3. Al Jadaan, O., Rao, C. R., Rajamani, L. Non-dominated ranked geneticAlgorithm for solving multi-objective optimization problems: NRGA.*Journal of Theoretical and Applied Information Technology*. 2008, 18 : 60-67.
4. Alumur,S, Kara, B. Y. A new model for the hazardous waste location-routing problem. *Computers and Operations Research*. 2007, 34 :1406-1423.

5. Averbakh, I., Berman, O. Probabilistic Sales-delivery man and sales-delivery facility location problems on a tree. *Transportation Science*. 1995, 29 : 184-197.
6. Averbakh, I., Berman, O. Minimax p-traveling salesmen location problems on a tree, *Annals of Operations Research*. 2002, 110 : 55-62.
7. Barahona, F., Jensen, D. Plant Location with Minimum Inventory. *Mathematical Programming*. 1998, 83 : 101-111.
8. Barreto, S. S., Ferreira, C., Paixa, J. Santos, B. S. Using clustering analysis in capacitated location-routing problem. *European Journal of Operational Research*. 2007, 179 : 968–977.
9. Chen, J., Cheng, C., Huang, P. Supply chain management with lean production and RFID application: A case study. *Expert Systems with Applications*. 2013, 40 : 3389–3397.
10. Chen, C.L., Yuan, T.Y., Chang, C.Y., Lee, W.C., Ciou, Y.C. A multi-criteria optimization model for planning of a supply chain network under demand uncertainty. *Computer Aided Chemical Engineering*. 2006, 21 : 2075-2080.
11. Chopra, S., Sunil, M., Meindel, B., Peter, L. *Supply Chain Management: Strategy, Planning, and Operations*. Prentice –Hall Inc. Chapter 14, 1998.
12. Deb, K. *Multiobjective optimization using evolutionary algorithms*. Chichester, U.K: Wiley, 2001.
13. Duroc, Y., Kaddour, D. RFID potential impacts and future evolution for green projects. *Energy Procedia*. 2012, 18 : 91 – 98.
14. Emerson, D., Zhou, W., Piramuthu, S. Goodwill, inventory penalty, and adaptive supply chain management. *European Journal of Operational Research*. 2009, 119 : 130–138.
15. Ghiani, G., Laporte, G, Eulerian location problems. *Networks*. 1999, 34 : 291-302.
16. Jamil, M., Batta, R., Malon, D.M. The traveling repairperson home base locations problem. *Transportation Science*. 1994, 28 : 150-161.
17. Kim, T., Glock, C. On the use of RFID in the management of reusable containers in closed-loop supply chains under stochastic container return quantities. *Transportation Research. Part E*. 2014, 64: 12–27.
18. Shafiee, M. Maintenance logistics organization for offshore wind energy: Current progress and future perspectives. *Renewable Energy*. 2015, 77 : 182–193.

19. Shin, T., Chin, S., Yoon S., Kwon S. A service-oriented integrated information framework for RFID/WSN-based intelligent construction supply chain management. *Automation in Construction*. 2011, 20 : 706–715.
20. Tofighi, S., Torabi, S.A., Mansouri, S.A. Humanitarian logistics network design under mixed uncertainty. *European Journal of Operational Research*. 2016, 250 : 239–250.
21. Wu, T.H., Low, C., Bai, J.W. Heuristic solutions to multi-depot location-routing problems. *Computers and Operations Research*. 2001, 29 : 1393–1415.
22. Yu, V. F., Lin, S-W., Lee, W. Ting, C.J. A simulated annealing heuristic for the capacitated location-routing problem. *Computers and Industrial Engineering*. 2010, 58 : 288-299.

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