A Hybrid Meta-Heuristic algorithm for optimization location-routing problem of facilities in four echelon supply chain

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Abstract

During the last three decades, the concept of integrated decision making in the supply chain becomes one of the essential aspects of supply chain management (SCM). This concept explores the interdependence between facility location, flow allocation between facilities, transportation system structure, and inventory control system. This study presents a new form of the location-routing problem of facilities under uncertainty in a supply chain network for deteriorating items through taking environmental considerations, cost, and procurement time and customer satisfaction into account, to simultaneously minimize total system costs, maximal delivery time and emissions across the entire network and maximize customer satisfaction. The research problem is formulated in a mixed-integer nonlinear multi-objective programming. In order to solve the model, the combination of the two Benders decomposition algorithm and Lagrange multiplier liberalization, as well as the combination of red deer algorithm and annealing simulation, was proposed. For validation, the results of the proposed algorithm in different size examples are compared with the results of the exact method solution by MATLAB software. The mean error of the proposed algorithm for the objective function is less than 4% compared to the exact method in solving the sample problems. Besides, the results of the algorithm performance are investigated based on standard indices. The computational results show the efficiency of the algorithm for a wide range of problems with different sizes. The location decisions are interdependent, and the process of determining the optimal values of these variables interact together, which can lead to an optimal system with the least possible costs.

1. INTRODUCTION

There is a relationship between the location of the facilities and the vehicle's routing. Maranzana (1964) showed that transportation costs often influence the location of factories, warehouses, and product delivery. Some believe that Maranzana's research (1976) is one of the earliest studies of the location-routing problem and that, in many cases, the emphasis is on finding the shortest path instead of the desired vehicle routing. Besides, following the above discussion, Rand (1976) stated that many people in business are aware of the dangers of sub-optimization

through separate warehouses location and vehicle routing, which both scientists and people in business usually ignore this relationship. Since there were some considerations related to production and the environment, and on the other hand, the impact of the consumption of manufactured products, attention was paid to the evolutionary cycle of these changes and interactions in recent times (De Keizer et al., 2017). The provision and distribution issues of products have now become a concern for business units, and on the other hand, it attracted attention to environmental issues and global demand in the manufacturing unit's field to meet their demands in addition to meet customer requirements. In the current situation, a simple structure of the supply chain to transfer products from production to consumption was transformed into a chain. Each of these levels has a defined role. The management of such chains at both the macro and micro levels is a challenge that manufacturing units should encounter with them, and this process requires efficient management from a strategic point of view and need an effective design for this network from an operational perspective (Zhang et al., 2019).

In recent years, many researchers paid attention to supply chain subject. Supply chain (SC) is a set of methods used to effectively integrate and provide suppliers, manufacturers, distributors, and retailers to minimize system costs, produce and distribute goods in valid numbers at the right place, time and meet customer needs (Kovacic & Bogataj, 2015). On the other hand, the supply chain is a network of organizations that engage in processes and activities with an upstream to downstream relationship and produce value as products and services provided to the end customer (Dai et al., 2018). The goal of everyone in the supply chain is to increase competitiveness, or increase customer service; Because today, from the end customer's point of view, an enterprise unit alone is not responsible for the competitiveness of its products or services and the supply chain considers all the organizations involved; These cases illustrate the impact of cost and time on customer satisfaction (Kovacic & Bogataj, 2013). Much research was performed about the supply chain of deteriorating items, and while it is one of the most powerful tools for evaluating and allocating mathematical programming resources, much of this research was performed using the scientific program. In these studies, specific goals and constraints were examined, and most of them considered one or two goals (mainly increasing customer satisfaction and reducing costs). Time plays a significant role in the whole chain of deteriorating items, and if there is a delay in the chain process, there will be much financial loss to the products and demolition for the environment. To address this gap, studies in this contest attempt to cover goals that include the reduction of cost and procurement time and the enhancement of customer satisfaction for mathematical programming by combining multiple manufacturers, multiple suppliers, and multiple distributions. It is possible to collect and recycle products

as well as destroy products for storage. With the integration of the three mentioned goals with the supply chain in this study, productivity was significantly increased.

The purpose of this research is to design a mathematical model that will perform the best facilities location for supply chain about cost optimization, procurement time, and customer satisfaction. In the supply chain of this research, the manufacturer produces a new product and delivers it to a distant market, and then the distributor buys the product and sells it to the end customers. Since the product is deteriorating, both its quantity and quality may be reduced during the transportation process. Besides, end-customers are sensitive both to the retail price and to product freshness; Market demand, therefore, has random nature and is dependent on these two factors. According to the variable transportation times, the product freshness and market demand, the decisions of the three parties in this supply chain are very complex and may cause losses with improper performance. The primary purpose of this research is to develop a model to identify the optimal decisions that each component must make in order to stimulate the members of the chain to be more coordinated. Therefore they all benefit from the improved performance of the system. This study is structured as follows: in the second part, the literature on the subject is examined. In the third section, the multi objective mathematical model of optimization of in Supply Chain of Deteriorating Items is introduced; also, parameters, objective functions, and related constraints are described. In Section 4, the multi-objective optimization algorithms simulated annealing implemented, and in Section 5, the conclusions and suggestions for future research are presented.

2. LITERATURE REVIEW

Mukhopadhyay & Ma (2009) provided a comprehensive review of the logistics network design to support the diversification in future research. Much of the research literature, in this case, concerns the design of logistics network. It intends for a forward network in order to determine a direct network from supplier to end customer. Pishvaee et al. (2009) used an integer linear model to design an integrated direct and reverse logistic network. In order to minimize costs and maximize responsiveness, they solved the model using a genetic algorithm (GA) with variable Neighborhood Search. Baghalian et al. (2013) analyzed and investigated an integrated production and reproduction system in which they review the returned products and categorize them into three levels of good, medium, and weak. So each of these levels can utilize recovery facilities and recover based on time and cost. El Sayyed et al. (2010) presented a probability model with the integer for the design of a forward and reverse integrated logistics network that was examined in terms of demand uncertainty and return rates. The purpose of this model is to maximize overall profit. Gomasta et al. (2012) explored

several production planning methods that are used to deliver returned products to new product quality or reproducible quality levels. Chian-Son Yu et al. (2010) used a robust optimization model for probability logistics problems. Since the cumbersome computation in robust programming led to less applicability of this method, a contingency management problem was modeled here using a robust optimization model whose solutions are less sensitive to the data in the scenario set. Pishvaee et al. (2011) used a robust optimization method under uncertainty to design a closed-loop multi-class supply chain network. To do this, they first designed a linear integer mixed model and then, using Ben-Tal & Nemirovski (2000) method, they developed the robust model and then compared the resulting model with the deterministic model using a few examples. Yoo, Kim, and Park (2012) considered the information available for the magnitude of the orders of a single-period recycling production network and propose two recycling options, and referred to the incompleteness of the inspection process and its cost recovery. Pishvaee & Razmi (2012) have designed a two-objective model under the inherent uncertainty of input data for the environmental supply chain network. Then they used a product based life cycle assessment approach for greening their design and applied a fuzzy method to solve it. Nance & Nickolides (2012) proposed a multilevel MILP-based model with apparent demand and return values. They assumed that third-party collection centers had batches of returned products that could be rejected or selected by recycling facilities. On the other hand, this model could select the part of the required category, and the value of products that had a certain quality level in each category was specified. Yoo etal. (2012) examined the information available in current ordering decisions for a single-period recycled production network. There were two recycling options available in the study, but the inspection process was incomplete, which could be improved with individual costs. Das & Chadari (2012) used a MIP model which was focused on product planning in reverse logistics and then considered product design decisions and product quality. In another study, the supply chain of multiple deteriorating products provided by Gomasta et al. (2012) was also investigated using mathematical programming. Since deteriorating products an ample space in the dairy product market, they require careful inventory control. Since there is a rapid movement of these products from distributor to retailer, some instructions are needed in the transportation system to maximize profits. In this research, the supply chain design is presented based on the variable demand and two types of customers for different deteriorating products to maximize the revenue while minimizing the inventory and transportation costs and thus maximal net profit. This model considers the constant shortage, the coordination and disposal cost, and the cost of products sale that declined over time. Doss & Dutta (2013) examined three options maintenance, reproduction, and recycling, using the dynamic system in an integrated reverse network. They also

modeled return quality as a constant percentage of recyclable products. The focal point of this work, on the other hand, was to simulate network behavior using conventional methods without initial cost. Baghalian et al. (2013) designed a multiproduct supply chain network and used a robust approach to deal with uncertainty while considering demand and supply-side uncertainties. This model was evaluated in the agricultural food industry. Katsaliaki et al. (2014) also proposed a game-based approach to facilitate decision making about deteriorating products. The blood chain game is presented, which designs the blood supply chain of donors to patients based on the actual modeling of the UK blood supply chain. The game attempts to optimize the performance of the chain through process analysis and proposes a solution to optimize patient profit cost-effectively and attempts to synchronize demand and supply of blood and maximize the entire supply chain value. Nagurney (2015) assessed sustainable supply chain design for sustainable cities. The supply chain, the necessary infrastructure for the production, distribution of products, and services in a network economy, provides a network for production, transportation, and consumption of a range of food products, clothing, automotive, and high-tech products. Cities serve as the main population centers as the main demand points, as well as the many distribution centers and provide storage facilities, transport providers, and even manufacturers. Morganti & Gonzalez (2015) investigated public procurements for deteriorating products by the case study of the Parma food hub in Italy and through mathematical modeling. This study analyzed plans for food delivery to urban distributors such as corporate retail chains, independent retailers and hotels, restaurants, and catering. The case study is Parma Italy, which has traffic regulations, delivery services, and an urban distribution center to improve efficiency and reduce the adverse effect of urban food distribution.

Similarly, Kovačić et al. (2015) reported the location and deviation of lead time in multilevel assembly systems of deteriorating products in Spanish food logistics. The current economic crisis is influenced by less capacity expansion or even capacity shrinkage, which is related to intermittent and reduced lead time activities. However, the location of suppliers is strongly related to the quality of agricultural products. Transport from distant places can significantly affect the food business in all aspects.

Todays, refrigerated vehicles are used to transport deteriorating foods such as frozen foods, fruits and vegetables, and temperature-sensitive chemicals. In order to design a sustainable supply chain to post-harvest losses and harvest scheduling equilibrium, a bilateral sustainable optimization model in which a food company maximizes its profits and post-harvest losses by expanding process facilities such as location and logistics proper determination of the purchase price minimizes. In contrast, a group of farmers all non-embedded distributor elementary, harvest, transport, storage, and decision market under the uncertainty of the product and the market equilibrium

considered by An & Ouyang (2016) is presented (An & Ouyang, 2016). According to the evolution of the agricultural sector and the new challenges, active management in agricultural supply chains is an attractive title for research. Therefore, uncertainty management in agricultural supply chain management was also reviewed with the latest advances in the application of operational research methods for uncertainty management that occurs in agricultural supply chain management issues (Borodin et al., 2016).

In order to optimize supply chain network design, De Keizer et al. (2017) investigated logistic network design for deteriorating products with a quality decline period. During the logistics period, the environmental conditions during the operation significantly affect the performance of the logistics network of fresh crops. Federikson (2017) analyzed the municipal service centers in Brazil and Sweden and indicated the performance of optimal allocation of these centers using public data. Then, based on the proposed optimization, the incompatibility criteria for public service allocation are presented regarding the literature on the subject, and it is shown how such incompatibility criteria can be related to economic, social, and political income and other variables. Mousavi et al. (2017) introduced a two-objective model for green truck planning and routing problem in a cross-warehouse system. This model identifies three critical decisions in crossover warehouse: 1) Sequence and schedule of incoming trucks at the reception door; 2) Determine a trail and incoming trucks schedule at the transportation door and 3) Determine the exit truck routes to the customer.

Rafei Majd et al. (2018) presented a three-layer supply chain comprising suppliers, the number of distribution centers, and the number of retailers (customers) in which products are delivered to customers within a limited time horizon. Retailer demand is random and follows the normal distribution with a mean and standard deviation. In this paper, the Lagrangian relaxation method is used to solve the model and determine the lower bound. A heuristic algorithm is also used to optimize the results of the Lagrangian relaxation algorithm and determine the upper bound. Rasi (2018) is provided a reverse logistics network and a MILP is developed to optimize the two objectives i.e. cost and time by a new fuzzy approach. Mogal et al. (2018) presented a new multi-period, multi-model, and multipurpose time-resolved mathematical model to support the Indian government decision-making process. The two objectives of minimizing cross-chain supply chain cost and total lead time were implemented using two Pareto models based on multi-objective algorithms with calibration parameters. Various factors, such as initial setup cost, transportation cost, inventory cost, residence time, and transfer time, are included in the model. Daryan & Talebizadeh (2019) developed an economic production quantity model in a three-echelon supply chain composing of a supplier, a manufacturer and a wholesaler under two

scenarios. As the first scenario, they considered a return contract between the outside supplier and the supplier and also between the manufacturer and the wholesaler, but in the second one, the return policy between the manufacturer and the wholesaler was not applied. Hafezalkotob & Zamani (2019) proposed a bi-level game-theoretic model to investigate the effects of governmental financial intervention on green supply chain.

This problem is formulated as a bi-level program for a green supply chain that produces various products with different environmental pollution levels. The problem was also regard uncertainties in market demand and sale price of raw materials and products. The model was further transformed into a single-level nonlinear programming problem by replacing the lower-level optimization problem with its Karush–Kuhn–Tucker optimality conditions. Sun & Wang (2019) investigated a reverse logistics production routing model by choosing a control policy for greenhouse gas emission. The purpose of this study was to select the optimal greenhouse gas control policy to follow the optimal production values, inventory, and delivery under the selected greenhouse gas control policy. In another study, Wu et al. (2019) studied the reverse logistic network optimization under fuzzy demand. The goal of recycling is to prevent the rapid depletion of natural resources. Another purpose is the conversion of waste to value for the economy.

3. PROBLEM STATEMENT AND RESEARCH MODELING

In recent years, many researchers and industrialists paid attention to the research in the supply chain context. Supply Chain is a set of methods used to effectively integrate and enable suppliers, manufacturers, distributors, and retailers to minimize system costs, produce and distribute goods in exact numbers at the right time and place and meet customer needs. On the other hand, supply chain is a network of organizations that engage in processes and activities with an upstream-downstream relation and create value as products and services delivered to the end customer (Dai et al., 2018).

The goal of everyone in the supply chain is to increase competitiveness, or increase customer service; Because today, from the end customer's point of view, an enterprise unit alone is not responsible for the competitiveness of its products or services and the supply chain considers all the involved organizations; These cases illustrate the impact of cost and time on customer satisfaction (Kovacic & Bogataj, 2013). In general, research purposes are as follows:

- Location of three-way logistics companies, retailers and distributors

- Coordination of chain levels to reduce cost and procurement time

- Create a balance between cost reduction and procurement time and increase customer satisfaction

Let consider a supply chain as Figure (1), which is a supply chain network. It has a four-level supply chain with one supplier (I), one manufacturer (j), one distributor (K), and costumers (L). In this research, we intend to locate them to optimize cost and delivery time and gain customer satisfaction properly.

Accordingly, the manufacturer provides the required raw materials by the triple part logistics companies of the supplier following their needs. After that, the manufacturer delivers the final product (e.g., yogurt) to the logistics companies during the manufacturing process, and the final product should be transferred to the market at the short time. The multi-objective optimization method was used to solve this model by GAMS software (CPLEX software solver) and the integrated Bender's decomposition algorithm and Lagrangian coefficient methods.

Figure (1) illustrates that the supply chain network has four levels, several suppliers, several manufacturers, distributors, and several retailers. In this research, we explore their suitable location to optimize the logistics time and cost and obtain customer satisfaction. Accordingly, the manufacturer supplies its raw materials to suppliers. After that, the manufacturer transfers its manufactured product to the distributor (s) in a short time. Distributors should deliver the products to several retailers after which may result in damage and demolition of product.

According to the mentioned discussion in the problem statement, three objective logistics were identified for the research problem. Different cost scenarios were addressed in various researches on cost reduction. Even in some studies, it was replaced by maximizing the profits from the difference between income and cost. The costs for this issue include the cost of establishing a location for production (Peterson & Sgersted, 2013; Pellegrino et al., 2019), a location for retailing (Li et al., 2018), transportation costs (Saif-Eddine et al al., 2019; Oh and Jeong, 2019; Pellegrino et al., 2019; Morto et al., 2019); production costs (Peterson & Sgersted, 2013; Wang et al., 2018; Ooh and Jeong, 2019; Cole & Aitken, 2019; Pellegrino et al., 2019; Reiman et al., 2019; Asim et al., 2019; Sun & Wang, 2019; Orjuela Castro et al., 2018; missing order costs (Wang et al., 2018), cost of inventory storage (Saif-Edin et al., 2019; Peterson & Sgstrand, 2013; Ooh and Jeong, 2019; Cole & Aitken, 2019), cost of returned and deteriorating items (Raeiman et al., 2019; Asim et al., 2019), transfer cost of returned items (Raeiman et al., 2019; Asim et al., 2019), environmental costs (Wu et al., 2019).

In recent studies, the required time for procurement was constant. For this reason, the logical relationship that was specified to avoid the sophisticated modeling between the time supplying time and the transportation cost was ignored. In the proposed fourth model, there is a reverse relationship between transportation cost and logistics time, as shown in Figure (2).

The next goal is the timing of the procurement, which is related to product quality, and the sensitivity of the deteriorating items. The timing of supply depends on variety of factors, regardless of the deterioration of durable products. There are several ways between the points (supplier and manufacturer/manufacturer and distributor / supplier and customer) to choose the shortest route in order to reduce both supply and transportation costs.

The type of vehicle intended for transportation is also of great importance. Because each vehicle has a certain capacity that is effective in the delivery schedule with a specified load, the type of transport route will be influenced by whether it is flat or mountainous at the delivery time (Liu et al., 2019; Dey & Saha, 2018; Kaur et al., 2018; Kaur & Singh, 2018; Niu et al., 2019; Asad et al., 2019; Chang & Lin, 2018).

With the reduction of delivery time, the product is delivered to the customer on time and results in customer satisfaction. Customer satisfaction elucidates itself in a variety of relationships, which the most important one is the timely delivery of the product and maintains the quality and the freshness of the product. The delivery time in this model is based on the period parameter index and includes the supplier's index, the manufacturing plant, and the type of delivery vehicle. In the proposed model, it is possible to select a vehicle. If the selected vehicles are expensive, the procurement time will be reduced.

The preparation time has a reverse relationship with the amount of greenhouse gas emissions that are specified in the standard tables. In air transport, for example, the supply time is short, but greenhouse gas emissions and transportation costs are high. In maritime transport, the relationship is reversed, meaning that the cost of emission and transfer of greenhouse gas is low, but the procurement time is high. Of course, it is possible to use marine transport in specific geographical locations.

Land transportation, like railroads and land routes, are specified and comparable in its standard tables. Fixed and operating costs related to the supplier, manufacturer's unit construction, distributor determination, and raw material transportation costs based on distance, product transfer costs from manufacturer to distribution to determine the cost function in this research. On the other hand, the related costs to the emission of greenhouse gases in the supplier selection, manufacturer's unit construction, distributor's unit construction, transportation from supplier to manufacturer, transportation from manufacturer to distributor and final product transportation are considered. The quality of the product must be at the right level. In order to minimize preparation time to compile the minimum function at the preparation time, the conditions for to maintain the quality and product freshness must be considered.
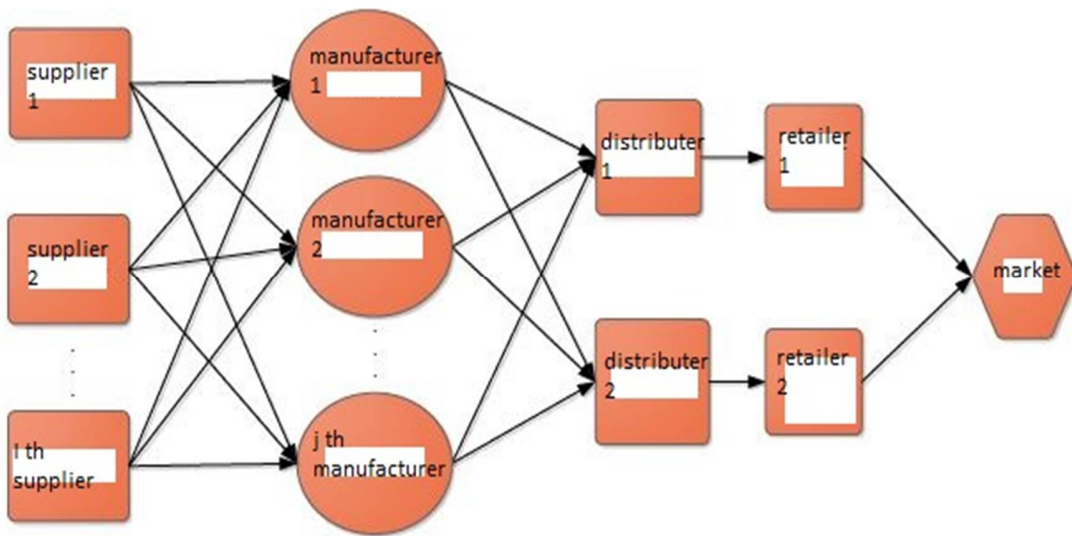
FIGURE 1
DISTRIBUTION NETWORK IN THE STUDIED SUPPLY CHAIN

As the shorter the preparation time leads to higher customer satisfaction, another function is designed for customer satisfaction. For example, Wang et al. (2018) used pricing process for customer satisfaction. Gölgeci et al. (2018) considered and designed the chain behavior as a factor of satisfaction. Khosroshahi et al. (2019) and Ardalan et al. (2016) examined the demand to increase customer satisfaction. Beton & Maloni (2005) consider the satisfaction factor as the relationship between the customer and the vendor. In this research, the freshness level and quality of products were used in the customer satisfaction function.
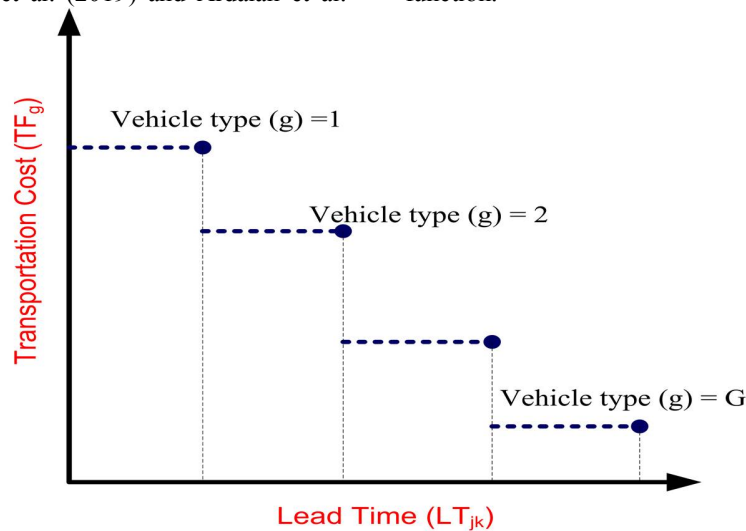

FIGURE 2
THE RELATIONSHIP BETWEEN PROCUREMENT TIME AND TRANSPORTATION COST

4. RESEARCH ASSUMPTION

The assumptions of mathematical model would be as following:

- Products are transported through a range of distributors to a set of retailers or customers. Distributors perform direct delivery to retailers.
- A time window is set for each customer
- The same vehicle is not used for transportation.
- The time period is one week.
- There are not pre-determined vehicles for suppliers and retailers
- Manufacturers and distribution centers have limited capacity.
- Distribution centers meet the requirements of retailers and manufacturers meet the distributors' needs.
- Suppliers and retailers are allowed to store goods and can order more than they need.
- A variety of products are considered.
- Smart sellers and distribution centers cannot return their orders.
- The delivered item has a specific time and transportation cost.
- Each unit has a specific travel cost and distance.
- All customer requirements must be met, with the assumption that they can buy from multiple distributors.
- Fixed cost (FCT) equipment must be considered for the cost of intra-network transportation.
- The desired supply chain network is related to the multi-product model.
- The supply chain is of the pull-type.
- The desired planning horizon is the pull-type.

4-1 Indices

I: set of suppliers $i \in \{1,2,...,I\}$

J: set of production centers $j \in \{1,2,...,J\}$

K: set of distribution centers $k \in \{1,2,...,K\}$

L: set of customers $l \in \{1,2,...,L\}$

P: set of products $p \in \{1,2,...,P\}$

τ: set of raw materials $\tau \in \{1,2,...,\tau\}$

M: set of transportation facilities $m \in \{1,2,...,M\}$

T: time period $t \in \{1,2,...,T\}$

G: group of products $g \in \{1,2,...,G\}$

A: Supplier capacity a $a \in \{1,2,...,A\}$

B: Manufacturer capacity b $b \in \{1,2,...,B\}$

C: Distributer capacity c $c \in \{1,2,...,C\}$

4-2 Parameters

$\tilde{\theta}_{lt}^{p}$: Customer demand I for product p over time period t

$\omega_{\varphi t}$: Consumption of raw materials τ in the production of p product over time period t

ϕ_{pgt}: Product group g from p product over time period t

$\tilde{S}_{i\tau}^{at}$: Maximum supply capacity, supplier i with capacity a level for raw materials τ over time period t.

$\tilde{M}_{jp}^{bt}$: Maximum production capacity by manufacturer j with capacity level b for product p in time period t

$\tilde{D}_{kg}^{ct}$: Maximum distribution capacity, k distributor with capacity c level for p product group in time period t

$\hat{A}_{it}$: Minimum number of selected suppliers i in time period t

$\hat{B}_{jt}$: Minimum number of selected manufacturer j in time period t

$\hat{C}_{kt}$: Minimum number of selected distributer k in time period t

$\tilde{F}_{ij}$: Spatial distance between supplier I and manufacturer j

$\tilde{W}_{jk}$: Spatial distance between manufacturer j to distributer k

$\tilde{H}_{kl}$: Spatial distance between distributer k to customer I

σ_{τ}: Raw material unit τ

V_{p}: Product unit p

E_{it}^{a}: Fixed and operational costs of selecting supplier i with capacity a at time t

Q_{jt}^{b}: Fixed and operational cost of providing a manufacturer j with a capacity level b over time period t

N_{kt}^{c}: Fixed and operational cost of providing a distributer k with a capacity level c over time period t

R_{m}: The cost of each unit of transport of raw materials based on the distance between the levels according to the type of transport facility m

U_{m}: The cost of each unit of transport of the product based on the distance between the levels according to the type of means of transport m

$\in_{it}^{a}$: The cost of emitting greenhouse gases is the choice of supplier i with capacity a in the time period t

η_{jt}^{b}: The cost of emitting greenhouse gases is the choice of manufacturer j with capacity b in the time period t

ν_{kt}^{c}: The cost of emitting greenhouse gases the construction of a distributor k with a capacity level c over time t

$\widetilde{\lambda}_{m}$: Greenhouse gas emission coefficient of each raw material transport unit based on the distance between levels according to the type of vehicle m

$\widetilde{\mu}_{m}$: Greenhouse gas emission coefficient of each raw material transport unit based on the distance between levels according to the type of vehicle m

4-3 Decision variables
Integer variables:

$\alpha_{it}^{a} = \begin{cases} 1 \\ 0 \end{cases}$: The binary variable, if the supplier i is selected

with a capacity level a in time period t, is equal to 1, otherwise it is equal to zero.

$\beta_{jt}^{b} = \begin{cases} 1 \\ 0 \end{cases}$: The binary variable, if the manufacturer j is constructed with capacity b at time t, is equal to 1, otherwise it is equal to zero.

$\gamma_{kt}^{c} = \begin{cases} 1 \\ 0 \end{cases}$: The binary variable, if the distributer k is constructed with capacity c at time t, is equal to 1, otherwise it is equal to zero.

Non negative variables:

$\widetilde{X}_{ij}^{\,tm}$: The amount of raw materials transferred t from the supplier i to the manufacturer j in the time period t according to the type of means of transport m

$\widetilde{Y}_{jk}^{\,ptm}$: The amount of product p transferred from manufacturer j to distributor k over time t according to the type of vehicle carrying m

$\widetilde{Z}_{kl}^{\,ptm}$: The amount of transferred product p from the distributer k to customer l in the time period t according to the type transportation facility m.

5. OBJECTIVE FUNCTIONS

The first objective function minimizes costs, including the first part, the fixed and operating cost of supplier selection; the second part, the fixed and operational cost of manufacturer unit construction; the cost of transporting raw materials based on the distance; the fifth part, the transportation cost of the product from the manufacturer to distributor, sixth part, costs of each product unit from the manufacturer to the customer.

The second objective function minimizes environmental pollution so that the first part of this function is the cost of greenhouse gas emissions; the second part is the cost of greenhouse gas emissions, the third part is the cost of greenhouse gas emissions. The fourth part is the cost of greenhouse gases emission due to raw material transportation from supplier to manufacturer, the fifth part is the cost of greenhouse gases emissions due to the transportation of the product from the manufacturer to distributor, and the sixth part is the cost of greenhouse gases emissions, due to the product delivery from distributor to customer.

The third and fourth objective functions are customer satisfaction functions by minimizing transportation time and lost sales levels.

Constraint (5) ensures that the amount of transferred raw material from supplier to manufacturer does not exceed the maximum supply capacity of the supplier. Constraint (6) indicates that the number of transferred products from the manufacturer to the distributor should not exceed the maximum capacity of the manufacturer. Constraint (7) indicates that the maximum distribution capacity, the distributor k with the capacity level for the product group g in the period should not exceed the defined capacity level. Constraint (8) indicates that the amount of transferred raw material from the supplier to the manufacturer must be at least equal to the amount of raw material required to produce all the planned products so that we do not suffer from a shortage of the required raw material.

Based on the constraint (9), the amount of product transferred from the manufacturer to the distributor must be at least equal to the amount of product transferred from the distributor to the customer so that we do not suffer from shortages. Constraint (10) ensures that the amount of product transferred from the distributor to the customer is at least equal to the customer's demand. This will prevent lost sales.

Constraint (11) indicates that a maximum of one supplier should be selected in each time period. Constraint (12) also keeps the number of manufacturers at a maximum of one at a time. Constraint (13) also considers the number of distributors in each period to be at most 1. Constraints (14) to (16) indicate that the minimum number of suppliers must be equal to the selected suppliers. Constraint (17) is also logical constraints of the problem.

$$Min \quad F_{Eco} = \sum_i \sum_a \sum_t E_{it}^a . \alpha_{it}^a + \sum_j \sum_b \sum_t Q_{jt}^b . \beta_{jt}^b + \sum_k \sum_c \sum_t N_{kt}^c . \gamma_{kt}^c$$
$$+ \sum_i \sum_j \sum_\tau \sum_t \sum_m \widetilde{F}_{ijt} . R_m . \sigma_\tau \widetilde{X}_{ij}^{\tau tm} + \sum_j \sum_k \sum_p \sum_t \sum_m G_{jkt} . U_m . V_p . \widetilde{Y}_{jk}^{ptm}$$
$$+ \sum_k \sum_l \sum_p \sum_t \sum_m \widetilde{H}_{kl} . U_m . V_p . \widetilde{Z}_{kl}^{ptm} \tag{1}$$

$$Min \quad F_{Env} = \sum_i \sum_a \sum_t \in_{it}^a \alpha_{it}^a + \sum_j \sum_b \sum_t \eta_{jt}^b . \beta_{jt}^b + \sum_k \sum_c \sum_t v_{kt}^c . \gamma_{kt}^c$$
$$+ \sum_i \sum_j \sum_\tau \sum_t \sum_m \widetilde{F}_{ijt} \lambda_m . \sigma_\tau \widetilde{X}_{ij}^{\tau tm} + \sum_j \sum_k \sum_p \sum_t \sum_m G_{jkt} . \mu_m . V_p . \widetilde{Y}_{jk}^{ptm}$$
$$+ \sum_k \sum_l \sum_p \sum_t \sum_m \widetilde{H}_{kl} . \mu_m . V_p . \widetilde{Z}_{kl}^{ptm} \tag{2}$$

$$Min \quad F_{delivery-time} = \sum_i \sum_m \sum_j \sum_k \sum_t \left(\frac{\widetilde{\theta}_{lt}^p}{R_m + U_m} \right) \widetilde{Y}_{jk}^{ptm} \tag{3}$$

$$Min \quad F_{Backorder-level} = \sum_t Max \sum_p \sum_k \widetilde{Z}_{kl}^{ptm} \tag{4}$$

$$\sum_j \widetilde{X}_{ij}^{\tau t} \le \sum_a \widetilde{S}_{i\tau}^{at} . \alpha_{it}^a \quad \forall i, \tau, t \tag{5}$$

$$\sum_k \widetilde{Y}_{jk}^{pt} \le \sum_b \widetilde{M}_{jp}^{bt} . \beta_{jt}^b \quad \forall j, p, t \tag{6}$$

$$\sum_l \sum_p V_p \widetilde{Z}_{kl}^{pt} . \phi_{pgt} \le \sum_c \widetilde{D}_{kg}^{ct} . \gamma_{kt}^c \quad \forall k, g, t \tag{7}$$

$$\sum_j X_{ij}^\tau \ge \sum_k \sum_p \widetilde{Y}_{jk}^p \omega_{\tau pt} \quad \forall j, \tau, t \tag{8}$$

$$\sum_j \widetilde{Y}_{jk}^{pt} \ge \sum_l \widetilde{Z}_{kl}^{pt} . \alpha_{it}^a \quad \forall k, p, t \tag{9}$$

$$\sum_k \widetilde{Z}_{kl}^{pt} \ge \widetilde{\theta}_{lt}^p \quad \forall l, p, t \tag{10}$$

$$\sum_a \alpha_{it}^a \le 1 \quad \forall i, t \tag{11}$$

$$\sum_b \beta_{jt}^b \le 1 \quad \forall j, t \tag{12}$$

$$\sum_c \gamma_{kt}^c \le 1 \quad \forall k, t \tag{13}$$

$$\sum_i \sum_a \sum_t \alpha_{it}^a \le \hat{A}_{it} \tag{14}$$

$$\sum_j \sum_b \sum_t \beta_{jt}^b \le \hat{B}_{jt} \tag{15}$$

$$\sum_k \sum_c \sum_t \gamma_{kt}^c \le \hat{C}_{kt} \tag{16}$$

$$\widetilde{X}_{ij}^{\tau t}, \widetilde{Y}_{jk}^{pt}, \widetilde{Z}_{kl}^{pt} \ge 0 \quad \& \quad \alpha_{it}^a, \beta_{jt}^b, \gamma_{kt}^c = 0,1 \tag{17}$$

6. MODEL SOLUTION WITH HEURISTIC METHODS

The proposed model relates to the complex nonlinear problem of integers and multi-objective under uncertainty conditions. According to Bridge (2011), first the binary variables of decision making for the organization of the supply chain are determined, and then the correct and continuous variables that show the volume of products and displacements are expressed. For the initial optimization, which shows multiple objectives, the Bandegers-Lagrangian release rate hybrid decomposition method is used, and for the second stage, the performance optimization that is expected for each solution (Omid Riazi CSL) is calculated and limited. Updates related to the model are updated. The SCIP, which is expressed in the solution method, is in fact software that optimizes mixed linear programming and is based on the combined method of Banders analysis and Lagrangian coefficient. In the constraint method, one of the approaches is to solve problems in to face multi-objective modes through objective functions transfer other than to the constraint.

7. COMPUTATIONAL RESULTS

To perform the research calculations, MATLAB software and the combined method of Banders analysis and Lagrangian coefficient were used and results are obtained based on the studied data tables,. Besides, the relative stability weight of the answer (w) is equal to 0.5 and the relative stability weight of the model (ω) is considered to be 5000.

TABLE 1
CHAIN SHEDDING PROGRAM RESULTING FROM SOLVING THE PROPOSED MODEL

12	11	10	9	8	7	6	5	4	3	2	1	Factory	Product
									308	359	19.5	1	1
					200	435	330	653	750	821	205	2	
					263	320	120	590	496		232	3	
		90.3		584	200	223		994	656	1137	905	1	2
				920	860	540	680	561	212	194	458	2	
		560	670	936		307	570	40				3	
	400	327	530	100	100	120			249	235	295	1	3
	550	593	620	300		90	160	830	768	970	200	2	
							250	780	102		39.6	3	
				353	237	130		407	729	283	482	1	4
			833	387	427	280	930	626	655	516	767	2	
				107			200	226				3	
		370	353	183	483	753	991	1047	717	1090	742	1	5
				277			170		230				
				66.5	320	164	367	73.4		5.8	399	2	
						170	280						
			349	20		277	598	333	150	170	70	3	

Tables 1 to 3 provide an overview of the results of supply chain planning that outline the supplier's selection method and demand response. The supplier → site or site → customer's terms were used to showing the appropriate solution. The first phrase means the supply of raw materials is required by the site j from the supplier i, and the second phrase means the response to customer needs through the site j. The empty cells in Table 1 are zero, meaning that the product was not delivered to the customer during the ordering period. On the other hand, in the first column, the type of product, in the second column, the active sites for each product, and in the third column, the production type in different periods are included. These types of considerations can be extracted in the transportation system specified in Table 1.

Table 2 shows the contrast between supply chain entities (the transfers that take place between the chains by the transportation system). As expected, the demand for factories and customers was met by close sources. However, several shortcomings were not compensated by the disconnected communications cost between suppliers and demand, considering other costs. On the other hand, in the downstream flow, the two parts are not well solved, which is related to site2 → customer's zone1 and site2 → customer's zone3 and for two reasons, adjustments may occur that are made to the marginal constraints and the changes that may occur in refilling the replenishment inventory in Factory No. 2 in various iterations.

TABLE 2
TRANSPORTATION PLANNING OBTAINED FROM SOLVING THE PROPOSED MODEL

				Period t								Factory	Product	
12	11	10	9	8	7	6	5	4	3	2	1			
									1	2	6	1	1	transportation
								2	5	5	5	2		
								3	8	8	8	3		
					1	1	1	1	1	4	6	1	2	
						2	2	2	4	10	10	2		
4	4	5	7	7	10	10	10	10	10	17	22	3		
8	8	8	8	8	8	8	8	88	8	8	15	2	3	
											5	3		
										2	3	1	4	
3	3	3	3	4	4	4	6	9	9	7	6	1	5	
								1	1	4		1	1	Customer
						2	3					2		
						3	5					3		
			1						3	2		1	2	
				2					6			2		
	1	2	3						7	5		3		
										6		1	3	
									7			2		
									5	15		3		
									3		6	1	4	
								2		3		2		
			1			2	3					1	5	
										10		2		
									2	1		1	4 → 5	

Table 3 shows the interactions between the supply chain and the different values of the ω coefficient. For example, when ω = 1500, 12 construction sites are upgraded to level 1 and site 3, from level 2 to level 3, and 2 construction sites are upgraded from level 1 to level 2, from level 3 to level 5.

TABLE 3
EFFICIENCY IMPROVEMENT OF THE CHAIN LEVEL AGAINST THE MODEL STABILITY FACTOr

			Period t								factory	Level improvement	ω
11	10	9	8	7	6	5	4	3	2	1			
						5					2	2 → 5	500
							8				2	3 → 5	
	1										2	2 → 3	1500
										12	3	2 → 3	
2											1	3 → 5	
										12	3	2 → 3	2000
									1		1	2 → 4	
										3	3	1 → 3	3500
										12	3	2 → 3	

Since the general programming model of several random objectives is presented, a problem of four objectives is the correct integer number, and its objective functions conflict with each other. According to this method, which was mentioned in the literature review section, first, by considering each of the objective functions separately and solving the problem of two or more goals, we get the optimal answer of each objective function individually. In order to emphasize on the importance of the four simultaneous general losses objectives in the production system and the supply chain and customer satisfaction, two models were discussed for further analysis:

Model 1
- This model includes the total objective function minimization of the total loss in the production system and supply chain while considering the specific constraints of this goal.

Model 2
- This model includes maximizing customer satisfaction by minimizing the maximum number of deficiencies among all customer aspects and in all periods while taking the specific constraints of this model into account.

Model 3
- This model is an integrated objective function that results from the standard combination of the deviation rate of the first and second objective functions from the optimal value available to them. As the constraints are considered for both models, after that value, it is changed, and based on that, various multi-objective planning issues are proposed and solved. Figure 3 shows the graphical chart of the balance between the and values for different values of, which starts from zero and ends in one.
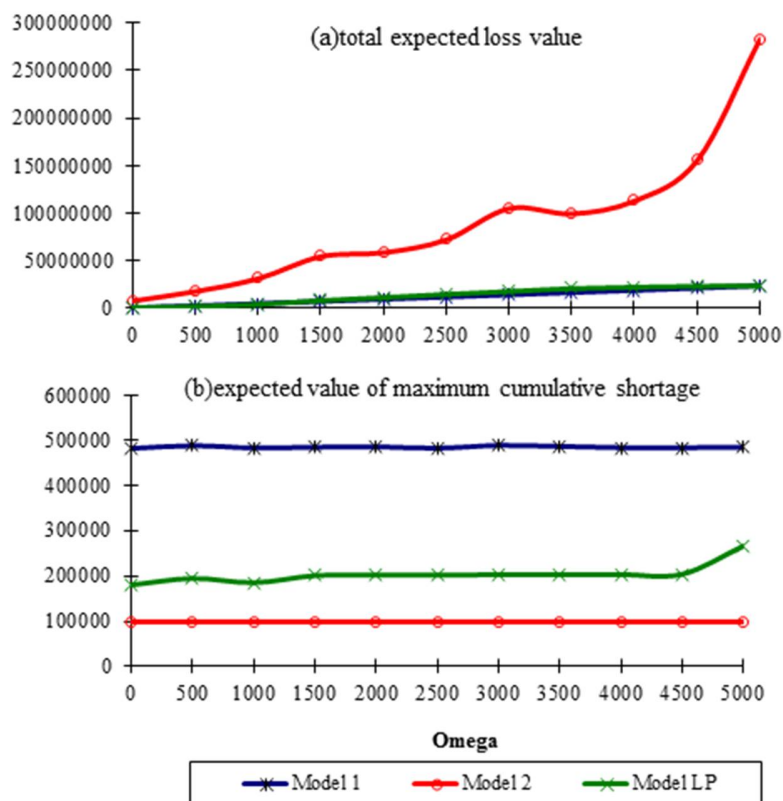

FIGURE 3
BALANCE BETWEEN MODEL ROBUSTNESS AND Z1 AND Z2 FUNCTIONS

Note that when the $\bar{w}$ value is equal to one, the defined model for the integrated objective function, are same as model 1, and when it is equal to zero, the model defined for the integrated objective function becomes as same as model 2. In model 1, the best value (Z_1^*) and in model 2 the worst value (Z_2^*) are obtained for $\bar{w}$ equals to 1.

In contrast, the worst value for model 1 and the best value for model 2 is zero. In fact, if we consider one of the objective functions, it can remove its objective model. Comparisons show that if a model of an integrated objective function is defined, it can create a relative equilibrium between two opposing objective functions. Figure 4, which shows an efficient Pareto curve makes the decision maker free to choose the best answer based on his or her relative preferences from non-dominant responses. Figure 3 shows the sensitivity analysis on the model

stability factor for single-objective models 1 and 2 and the integrated two-objective model. Figure 4-A shows that the value of the objective function Z_1 increases with increasing the ω value in model 2, but this increase in model 1 and the integrated model of objective function does not increase compared to model 2.
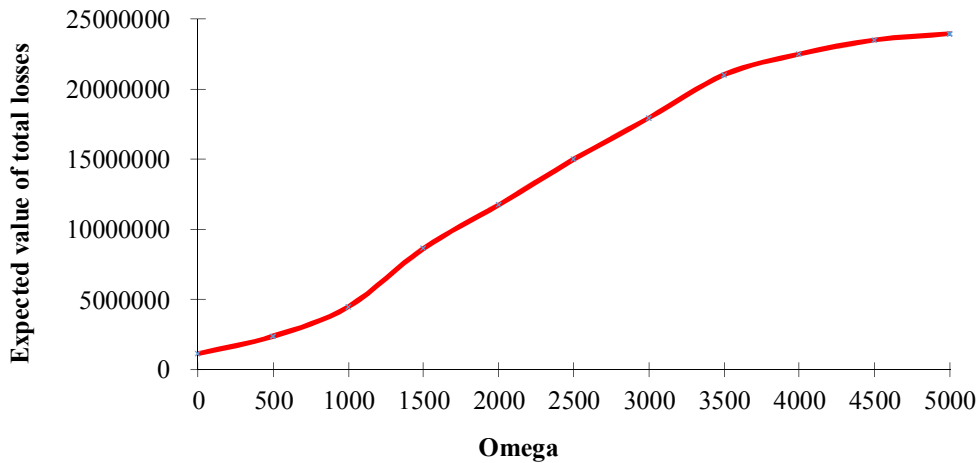

FIGURE 4
RELATIONSHIP BETWEEN MODEL ROBUSTNESS AND Z_1 VALUE FROM INTEGRATED OBJECTIVE FUNCTION MODEL

Figure 4 shows a sensitivity analysis of the stability of the model versus the stability of response to the first objective function (Z1) through the integrated objective function model. As expected, the increase in the amount of ω leads to an increase in Z_1, but over time the slope of this increases, is declined. To justify this, it can be stated that in model 2, there is no penalty for deviation from the unjustified solution. Figure 5-b shows the best value and the worst value for models 1 and 2, and these sensitivity values will not indicate the value of the model stability coefficient (ω). In this figure, it is determined that the behavior of the objective function is such that the values of Z_1, Z_2 are as close as possible to their optimal values of Z2 *, Z1 *.
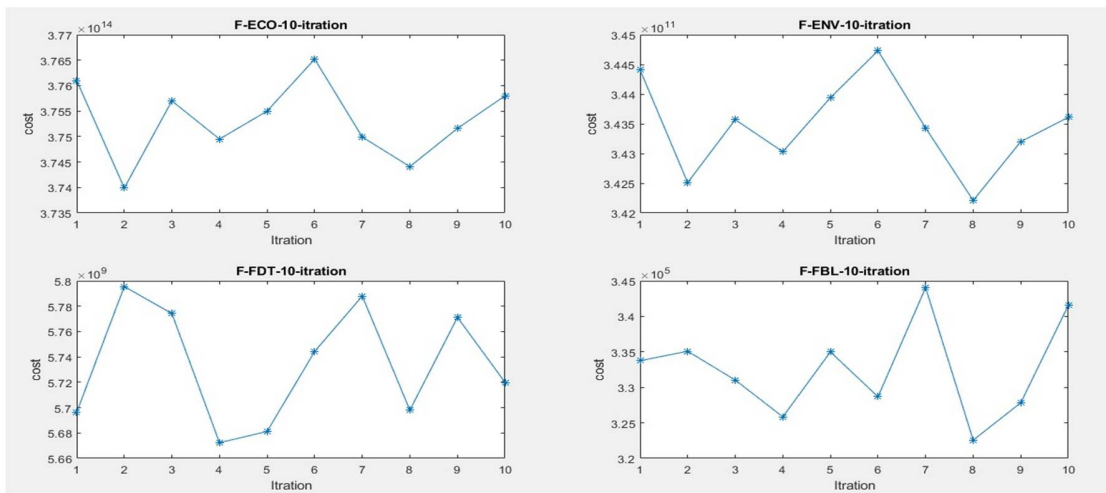

FIGURE 5
EXPECTED PERFORMANCE FOR OPTIMIZATION

The expected performance to optimize 10 solutions in 1 iteration is shown in Figure 4-4. Based on the results, the 1 to 4 solution is impossible, because the sale levels and services is zero. Solutions 6, 3, and 9 have a moderate level, which is also called insufficient. On the other hand, Solutions 5, 2 and 10 8 have the best expected performance. Other solutions are about 80 percent closer to the expected solution. When existing supply chain is compared with the proposed supply chain in table 4, it is clear that the operation costs 9 reduced 20%.

TABLE 4
OBJECTIVES OF THE OBJECTIVE FUNCTION FOR TEN ITERATIONS

Fixed and operational cost of construction of the manufacturer unit	Cost of Shortage	Transportation cost	The cost of greenhouse gases emission	Total cost	Iteration
424180	18135	155490	263960	992805	1
408225	15765	154800	242290	945580	2
423960	7229.4	157030	246500	963829.4	3
407805	2974	152060	253110	944579	4
411730	21877	154830	252900	968527	5
423200	15765	156350	244840	967735	6
411635	13685	155030	251140	958540	7
418470	4048	154180	242830	945948	8
408957	8881	150340	239610	934048	9
419070	23816	157850	251920	981056	10
415723.2	13217.54	154796	248910	960264.7	Expected value
6760.7712	7213.927	2235.85	7178.2805	18211.31	Standard deviation

At the same time, its environmental impact has improved by almost 20 times, and the service provided to the customer is also improved. These comparisons show that the presented network in all functional goals were robust. These cases indicate that the results obtained from the combined method are shown in Table 5 for four objective functions defined for the original model. According to Table 5, the results in iteration 1 provide better solutions than other iterations.

TABLE 5
RESULTS OF THE MAIN MODEL GOALS ACCORDING TO EACH ITERATION

Iteration	The objective function1	The objective function2	The objective function3	The objective function4
1	1.3438e+14	1.1292e+11	9.2604e+09	140628
2	3.7610e+14	3.4441e+11	5.6963e+09	333747
3	3.7399e+14	3.4251e+11	5.7955e+09	335087
4	3.7570e+14	3.4357e+11	5.7742e+09	331030
5	3.7495e+14	3.4303e+11	5.6723e+09	325840
6	3.7550e+14	3.4394e+11	5.6812e+09	334992
7	3.7652e+14	3.4473e+11	5.7443e+09	328672
8	3.7499e+14	3.4343e+11	5.7880e+09	344037
9	3.7441e+14	3.4221e+11	5.6980e+09	322564

8. MODEL SOLUTION WITH METAHEURISTIC METHOD

In this section, according to the main solution method stated in the problem statement section, which is the combined method of red deer and simulated annealing, we express the setting parameters before solution. Then the results of model solution will be shown.

PARAMETERS TUNING

The results of metaheuristic algorithms depend on the values of its input parameters, so we now describe how to set the values of the proposed parameters. In addition, the stop condition is twenty iterations. Experimental design methods are widely used in many systems. This is a very important tool for process performance and correction. Parameter tuning methods include:
Citation to former studies;
Trial and error method;
Complete tests method;
Taguchi method;

Response surface methodology;
Adaptive neural network and fuzzy neural network; and
Meta-heuristic algorithms (before or during execution).

In this dissertation, we used the Taguchi method. Dr. Genichi Taguchi expanded the range of experimental design knowledge. Parameter design method provided an engineering method for product or process design whose purpose was to minimize changes and the sensitivity of disturbance factors. In an efficient parameter design, the first goal is to identify and adjust the factors that minimize variable responses, and the next goal is to identify controllable and uncontrollable factors. Taguchi addressed

the concept of the loss function. The function combines loss, cost, objective, and variation, achieves a measurement criterion, and prioritizes the specifications constraints. In addition, he expanded the concept of robustness. The ultimate goal of this method is to find the optimal composition of the controllable factors amounts. The foundation of Taguchi philosophy is a robust and stable design. To use this method, we enter the window (DOE) using Minitab 16 software and select the Taguchi method. Here, it is necessary to determine the number of factors needed to determine the number and combination method of test levels and the number of levels.

TABLE 6
FACTORS AND CANDIDATE LEVELS IN THE RED DEER INTEGRATION ALGORITHM AND SIMULATED ANNEALING

Level values			Parameter
Level 3	Level 2	Level 1	
200	150	100	Maximum iteration
300	100	100	Population size
50	35	20	Number of males
0.8	0.6	0.5	Percentage of commanders
0.7	0.6	0.4	Percentage of inside the harems
0.5	0.5	0.3	Percentage of outside the harems

According to standard orthogonal arrays, the Taguchi L9 was selected as a suitable test design to adjust the proposed parameters. The L9 array is an experimental design with 9

tests. The experimental designs are shown in table (7) for the algorithm.

TABLE 7
L9 EXPERIMENTAL ARRAY EXPERIMENTAL DESIGN

Running sequence	Algorithm parameters						Responsible values
	outside	inside	commanders	Males	Population	iteration	MID
1	1	1	1	1	1	1	6.9517
2	1	2	2	1	2	2	37.162
3	1	3	3	1	3	3	3.0812
4	2	1	2	2	1	2	9.465
5	2	2	3	2	2	3	5.6565
6	2	3	1	2	3	1	9.5747
7	1	1	1	3	1	3	16.3752
8	1	2	2	3	2	1	14.2128
9	1	3	3	3	3	2	7.9231

The proposed metaheuristic algorithm is implemented for each Taguchi test, and then the mean ratio (S / N) for each level of the algorithm-related factors and the optimal levels of the input parameters of this algorithm is presented in

Table (8). Figure (6) shows the variation trend in the four functions of the research model based on the twelve periods with combined red deer algorithm and simulated annealing.

TABLE 8
OPTIMAL RESULTS OF EACH OBJECTIVE FUNCTION IN EACH PERIOD

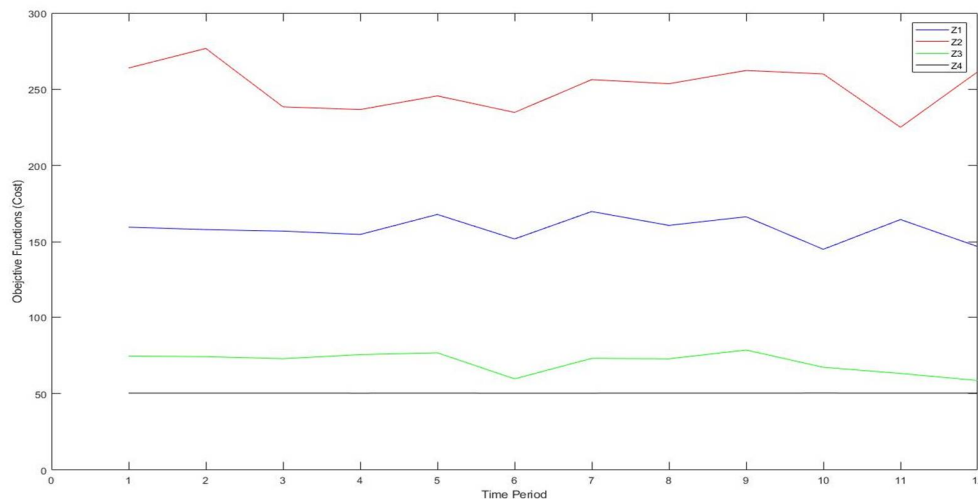| Period												Objective function
12	11	10	9	8	7	6	5	4	3	2	1	
146.78	164.52	144.99	166.34	160.66	169.78	151.77	167.86	157.71	156.91	157.92	159.5	1
261.46	225.04	260.03	262.31	253.63	256.31	234.80	245.64	236.69	238.45	276.77	263.94	2
58.57	63.18	67.21	78.50	72.75	73.03	59.64	76.66	75.49	72.82	74.17	74.57	3
50.29	50.31	50.35	50.32	50.32	50.28	50.26	5.31	50.28	5.31	50.34	50.30	7

FIGURE 6
THE TREND OF VARIATIONS IN OBJECTIVE FUNCTIONS OVER DIFFERENT TIME PERIODS

In the present research problem has four raw materials, five suppliers, five manufacturers, four distributors, and three customers. The values shown in the diagram above indicate the number of transferred products from one level to another. For example, the manufacturer 4 sends 89 units of the product produced in this unit from 100 produced item to the distributor 4 and 11 units of the remaining product to the distributor of 3. This diagram shows that the network optimization is such that attempts were taken to provide the required values for each level of the nearest unit from the previous level.

9. CONCLUSION AND RECOMMENDATION FOR FUTURE RESEARCH

In this study, random programming models are presented for overall production planning in the supply chain under uncertainty conditions. Approaches that include centralized integration of general planning decisions and supply chain planning comprise two necessary steps: In the first step, major pre-production decisions are made, such as the amount and how to supply the raw materials from suppliers, logistics planning and related transportation, production rate determination and human resource management in manufacturing plants. In the second step, when decision are performed about the first step, a decision is made about the value and the storage method of inventories, the value and distribution method of products to customers along with its logistical planning. Decisions about the first step are based on the value prediction values of parameters, and decisions about the second step are based on the actual values parameters. The presented model in this study includes four objective functions. The evaluation of the efficiency and usability of the model was conducted in the form of a case study, and then various sensitivities were analyzed to validate the model. The computational results from a set of real-time data showed that the model could consider integrated concepts such as customer satisfaction as tactical production decisions. With the concept of labor productivity, the model integrates human resource management decisions and makes the overall production plan more flexible with uncertainties in demand. The model also showed how international rules and regulations, such as environmental regulations, greenhouse gas emissions, and industrial waste, can influence overall program structures, as well as consider real nonlinear functions for discounts and shortages. It creates more realistic models and provides a clearer picture of what will happen in the future as the result of different scenarios. There are some limitations in this paper which can be addressed in future researches. At first, the case was limited to a small number of stations in periods in a relatively concentrated RSCM and there was an opportunity to explore more deeply the

numbers facilities. Second, in this study, researchers due to lack of access to local data contained in the company of this objective were avoided while other researchers have been suggested to minimize space for their goals. Third, this study only considered multi products due to the nature of the company, while other researchers are recommended to study in other industries.

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COMPETING INTEREST STATEMENT

The authors declare no conflict of interest.

ADDITIONAL INFORMATION

No additional information is available for this paper

References

[1] An, K., & Ouyang, Y. (2016). Robust grain supply chain design considering post-harvest loss and harvest timing equilibrium. Transportation Research Part E: Logistics and Transportation Review, Vol.88, pp.110-128.

[2] Ardalan, Z., Karimi, S., Naderi, B., & Khamseh, A. A. (2016). Supply chain networks design with multi-mode demand satisfaction policy. Computers & Industrial Engineering, Vol.96, pp.108-117.

[3] As' ad, R., Hariga, M., & Alkhatib, O. (2019). Two stage closed loop supply chain models under consignment stock agreement and different procurement strategies. Applied Mathematical Modelling, Vol.65, pp.164-186.

[4] Asim, Z., Jalil, S. A., & Javaid, S. (2019). An uncertain model for integrated production-transportation closed-loop supply chain network with cost reliability. Sustainable Production and Consumption, Vol.17, pp.298-310.

[5] Baghalian, A., Rezapour, S., & Farahani, R. Z. (2013). Robust supply chain network design with service level against disruptions and demand uncertainties: A real-life case. European Journal of Operational Research,Vol. 227(1), pp.199-215.

[6] Balaji, M., & Arshinder, K. (2016). Modeling the causes of food wastage in Indian perishable food supply chain. Resources, Conservation and Recycling, Vol.114, pp.153-167.

[7] Benton, W. C., & Maloni, M. (2005). The influence of power driven buyer/seller relationships on supply chain satisfaction. Journal of Operations Management, Vol.23(1), pp.1-22.

[8] Ben-Tal,A.,Nemirovski.(2000).Robust solutions of Linear Programming problems contaminated with uncertain data. Math. Program. Vol.88, pp.411–424. https://doi.org/10.1007/PL00011380

[9] Borodin, V., Bourtembourg, J., Hnaien, F., & Labadie, N. (2016). Handling uncertainty in agricultural supply chain management: a state of the art. European Journal of Operational Research, Vol.254(2), pp.348-359.

[10] Chian-son Yu, Hann-Lin Li.(2010).A robust optimization model for stochastic logistic problems. Int. J. Production Economics, Vol.64(2), pp.385-397.

[11] Cole, R., & Aitken, J. (2019). The role of intermediaries in establishing a sustainable supply chain. Journal of Purchasing and Supply Management.Vol.26(2),pp.100-123.

[12] Dai, Z., Aqlan, F., Zheng, X., & Gao, K. (2018). A location-inventory supply chain network model using two heuristic algorithms for perishable products with fuzzy constraints. Computers & Industrial Engineering.Vol19(3),pp.338-352.

[13] Daryan Noori,M,.Talebizadeh,At allah.(2019). Optimizing pricing and ordering strategies in a three-level supply chain under return policy. Journal of Industrial Engineering International,Vol.15(1),pp.73–80.

[14] Das, K., & Chowdhury, A. H. (2012). Designing a reverse logistics network for optimal collection, recovery and quality-based product-mix planning. International Journal of Production Economics.Vol.135(1),pp. 209–221.

[15] Doss, D., & Dutta, P. (2013). A system dynamics framework for integrated reverse supply chain with three way recovery and product exchange policy. Computers and Industrial Engineering, 66(4), pp.720–733.

[16] De Keizer, M., Akkerman, R., Grunow, M., Bloemhof, J. M., Haijema, R., & van der Vorst, J. G. (2017). Logistics network design for perishable products with heterogeneous quality decay. European Journal of Operational Research, 262(2), pp.535-549.

[17] Dey, K., Saha, S. (2018). Influence of procurement decisions in two-period green supply chain. Journal of cleaner production, Vol.190(6),pp. 388-402.

[18] El-Sayed, M., Afia, N., & El-Kharbotly, A. (2010). A stochastic model for forward–reverse logistics network design under risk. Computers & Industrial Engineering, Vol.58(3), pp.423-431.

[19] Fredriksson, A. (2017). Location-allocation of public services–Citizen access, transparency and measurement. A method and evidence from Brazil and Sweden. Socio-Economic Planning Sciences,Vol.(59),pp. 1-12.

[20] Gölgeci, I., Murphy, W. H., & Johnston, D. A. (2018). Power-based behaviors in supply chains and their effects on relational satisfaction: A fresh perspective and directions for research. European Management Journal, Vol.36(2), pp.278-287.

[21] Gumasta, K., Chan, F. T., & Tiwari, M. K. (2012). An incorporated inventory transport system with two types of customers for multiple perishable goods. International Journal of Production Economics.Vol.139(2), pp.678-686.

[22] Hafezalkotob,Ashkan,Zamani,Soma.(2019). A multi-product green supply chain under government supervision with price and demand uncertainty.Journal of Industrial Engineering International,Vol.15(1),pp.193–206.

[23] Katsaliaki, K., Mustafee, N., & Kumar, S. (2014). A game-based approach towards facilitating decision making for perishable products: An example of blood supply chain. Expert Systems with Applications.Vol. 41(9),pp. 4043-4059.

[24] Kaur, H., & Singh, S. P. (2018). Heuristic modeling for sustainable procurement and logistics in a supply chain using big data. Computers & Operations Research.Vol.98, pp.301-321.

[25] Khosroshahi, H., Rasti-Barzoki, M., & Hejazi, S. R. (2019). A game theoretic approach for pricing decisions considering CSR and a new consumer satisfaction index using transparency-dependent demand in sustainable supply chains. Journal of Cleaner Production, Vol.208,pp. 1065-1080.

[26] Kovačic D, Bogataj M (2013) Reverse logistics facility location using cyclical model of extended MRP theory. Cent Eur J Oper Res.Vol. 21(1),pp.41–57.

[27] Kovačić, D., Hontoria, E., Ros-McDonnell, L., & Bogataj, M. (2015). Location and lead-time perturbations in multi-level assembly systems of perishable goods in Spanish baby food logistics. Central European journal of operations research, Vol.23(3), pp.607-623.

[28] Li, L., Dababneh, F., & Zhao, J. (2018). Cost-effective supply chain for electric vehicle battery remanufacturing. Applied energy, Vol.226, pp.277-286.

[29] Maranzana, F.E.1964. On the location of supply points to minimize transport costs. Operational Research Quarterly Vol.15, pp.261–270.

[30] Mogale, D. G., Kumar, M., Kumar, S. K., & Tiwari, M. K. (2018). Grain silo location-allocation problem with dwell time for optimization of food grain supply chain network. Transportation Research Part E: Logistics and Transportation Review,Vol. 111, pp.40-69.

[31] Morganti, E., & Gonzalez-Feliu, J. (2015). City logistics for perishable products. The case of the Parma's Food Hub. Case Studies on Transport Policy, Vol.3(2), pp.120-128.

[32] Mukhopadhyay, S., & Ma, H. (2009). Joint procurement and production decisions in remanufacturing under quality and demand uncertainty. International Journal of Production Economics.Vol. 120(1), pp.5–17.

[33] Mousavi, M., & Rayat, F. (2017). A Bi-Objective Green Truck Routing and Scheduling Problem in a Cross Dock with the Learning Effect. Iranian Journal of Operations Research.Vol. 8(1), pp. 2-14.

[34] Nagurney, A. (2015). Design of sustainable supply chains for sustainable cities. Environment and Planning B: Planning and Design.Vol.42(1),pp. 40-57.

[35] Nenes, G., & Nikolaidis, Y. (2012). A multi-period model for managing used product returns. International Journal of Production Research, Vol.50(5), pp.1360–1376.

[36] Niu, B., Mu, Z., Chen, L., & Lee, C. K. (2019). Coordinate the economic and environmental sustainability via procurement outsourcing in a co-opetitive supply chain. Resources, Conservation and Recycling.Vol.146, pp.17-27.

[37] Oh, J., Jeong, B. (2019). Tactical supply planning in smart manufacturing supply chain. Robotics and Computer-Integrated Manufacturing, Vol.55, pp.217-233.

[38] Orjuela-Castro, J. A., Aranda-Pinilla, J. A., & Moreno-Mantilla, C. E. (2018). Identifying trade-offs between sustainability dimensions in the supply chain of biodiesel in Colombia. Computers and Electronics in Agriculture.

[39] Rasi,Ehtesha,Reza.(2018). A Cuckoo Search Algorithm Approach for Multi Objective Optimization in Reverse Logistics Network under Uncertainty Condition. International Journal of Supply and Operations Management (IJSOM).Vol.5(1),pp.66-80.

[40] Pellegrino, R., Costantino, N., & Tauro, D. (2019). Supply Chain Finance: A supply chain-oriented perspective to mitigate commodity risk and pricing volatility. Journal of Purchasing and Supply Management.Vol. 25(2), pp.118-133.

[41] Pettersson, A. I., & Segerstedt, A. (2013). Measuring supply chain cost. International Journal of Production Economics.Vol.143(2), pp.357-363.

[42] Pishvaee, M. S., & Rabbani, M. (2011). A graph theoretic-based heuristic algorithm for responsive supply chain network design with direct and indirect shipment. Advances in Engineering Software.Vol.42(3), pp.57-63.

[43] Pishvaee, M. S., & Razmi, J. (2012). Environmental supply chain network design using multi-objective fuzzy mathematical programming. Applied Mathematical Modelling.|Vol.36(8), pp.3433-3446.

[44] Pishvaee, M.S., Jolai, F. and Razmi, J. (2009). "A stochastic optimization model for integrated forward/reverse logistics network design." Journal of Manufacturing Systems, Vol. 28, pp. 107-114.

[45] Rafie-Majd, Z., Pasandideh, S. H. R., & Naderi, B. (2018). Modelling and solving the integrated inventory-location-routing problem in a multi-period and multi-perishable product supply chain with uncertainty: Lagrangian relaxation algorithm. Computers & Chemical Engineering.Vol.109, pp.9-22.

[46] Rand, G.K.(1976). Methodological choices in depot location studies. Operational Research Quarterly.Vol. 27, pp.241–249.

[47] Reimann, M., Xiong, Y., & Zhou, Y. (2019). Managing a closed-loop supply chain with process innovation for remanufacturing. European Journal of Operational Research.Vol.276(2), pp.510-518.

[48] Saif-Eddine, A. S., El-Beheiry, M. M., & El-Kharbotly, A. K. (2019). An improved genetic algorithm for optimizing total supply chain cost in inventory location routing problem. Ain Shams Engineering Journal.Vol.10(1), pp.63-76.

[49] Sun, S., Wang, X. (2019). Promoting traceability for food supply chain with certification. Journal of Cleaner Production.Vol. 217, pp.658-665.

[50] Wang, C. X., Qian, Z., & Zhao, Y. (2018). Impact of manufacturer and retailer's market pricing power on customer satisfaction incentives in supply chains. International Journal of Production Economics.Vol. 205, pp.98-112.

[51] Wang, X., Guo, H., Yan, R., & Wang, X. (2018). Achieving optimal performance of supply chain under cost information asymmetry. Applied Mathematical Modelling.Vol. 53, pp.523-539.

[52] Wu, T., Zhang, L. G., & Ge, T. (2019). Managing financing risk in capacity investment under green supply chain competition. Technological Forecasting and Social Change.Vol. 143, pp.37-44.

[53] Yoo, S. H., Kim, D., & Park, M.-S. (2012). Lot sizing and quality investment with quality cost analyses for imperfect production and inspection processes with commercial return. International Journal of Production Economics.Vol.140(2),pp. 922–933.

[54] Zhang, S., Lee, C. K. M., Wu, K., & Choy, K. L. (2016). Multi-objective optimization for sustainable supply chain network design considering multiple distribution channels. Expert Systems with Applications.Vol. 65, pp.87-99.