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A Multi Objective Optimization Model for Multi-commodity Closed-loop Supply Chain Network Considering Disruption Risk

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ABSTRACT

Recently, the difference in the most effective competencies is considered the main competitive factor in organizations. To this end, organizations seek to improve a number of their functional capabilities, expertise, and capacities to enhance their operational area. Therefore, when an organization focuses on the quality of its services or products, it is trying to improve maintainability to gain a competitive advantage. In this study, a closed-loop, multi-objective, multi-level, multi-commodity, and multi-period mathematical model for a supply chain with producer, and distributor components is presented to locate and allocate items. The presented model can control environmental, economic, and social factors along the chain. One of the most important and unique aspects of the current study is considering different scenarios in the closed-loop supply chain (CLSC) so that the quality of the produced and transported products is paid attention to according to perishability. In addition, to control environmental effects, the model can minimize total CO_2 emissions. The problem is solved on small, medium, and large scales using Epsilon Constraint and NSGA-II methods. According to the obtained results, the flow according to the boom scenario is more than the stagnation scenario. Finally, according to the sensitivity analysis, the number of centers established increases with an increase in demand. The results show that the non-dominated sorting genetic algorithm (NSGA-II) model can predict the behavior of the model well in the long term. For this purpose, Mean ideal distance (MID) index, has been used for evaluation of calculation. the value of standard MID is equal to 6.56 that shows the model accuracy is adequate.

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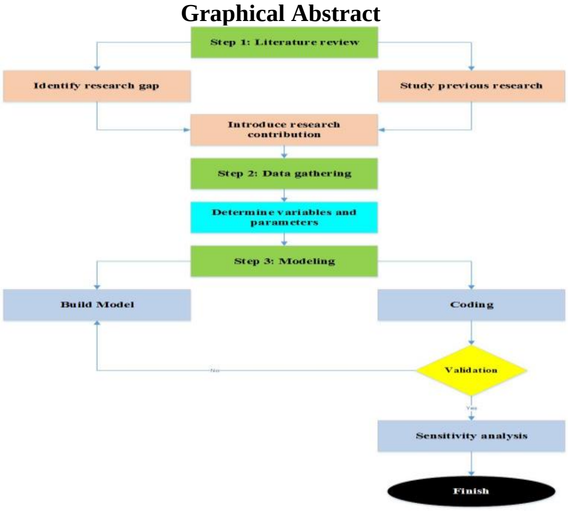
Graphical Abstract



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1. INTRODUCTION

Supply chain (SC) systems encompass a cohesive network of goods, services, and interrelated activities. Among the pivotal considerations in designing an efficient supply chain is the judicious selection of suppliers responsible for producing goods or delivering services. Thus, the act of choosing the right supplier emerges as a critical facet that enhances and optimizes the flow within the supply chain (1). In the contemporary landscape, supply chains have evolved into structured circuits that, in addition to their forward flows, also accommodate reverse flows. This paradigm is known as a closed-loop supply chain (CLSC), comprising a collaborative network of components operating in unison (2). CLSCs play a significant role in conserving substantial quantities of fossil fuels, non-renewable resources, water, and land through resource recycling; thus, leaving a noteworthy impact on the environment (3). Given the growing significance of environmental concerns, manufacturers and retailers have begun to collaborate on shared responsibilities to enhance the environmental design of products and CLSC efficiency (4). The quest for a more effective collaborative model to encompass various aspects has become a focal point of research (5). Furthermore, in numerous developed and progressive nations, attention has been directed towards the reverse supply chain and its implications on environmental sustainability (6). The reverse supply chain and reverse logistics, by considering the environmental impact of product manufacturing, have garnered significant attention (7-9). Dealing with yield management in a supply chain is a multifaceted endeavor that necessitates decision-making at both strategic and operational levels. High-level decisions encompass determinations regarding facility types, locations, and the control of planned returns (10, 11). Conversely, lower-level planning addresses issues such as intervals between waste material collection, the number and capacity of transportation vehicles, and the determination of optimal routes (12). These two management levels are intertwined, often necessitating separate reviews due to their closeness. Strategic decisions are typically imposed by upstream government institutions on downstream organizations, while operational decisions are enacted through downstream institutions. Therefore, the management of recycling-related issues must be studied concerning various product types (13-15). New logistics structures illustrate the utilization of closed-loop supply chain concepts, showcasing significant improvements in resource utilization efficiency (16, 17). In today's context, returned products have gained substantial importance, being recognized as valuable assets within the supply chain components (18). Reducing environmental impacts to preserve the environment represents one of the primary objectives of the reverse supply chain. Environmental conservation has taken precedence over the costs associated with collecting returned products, primarily due to the detrimental consequences of excessive carbon emissions from waste disposal on the environment and its resources (19). While reverse logistics focuses on the flow of returned products, a CLSC comprehensively addresses both forward and reverse supply chain operations. Therefore, not only are the two terms distinct, but reverse logistics also falls under the umbrella of the CLSC (20, 21). To ensure the success of any organization, proactive and continuous risk management throughout a project is imperative (22). Managing risk effectively across all levels of the supply chain's life cycle is essential. It's worth noting that project risk exists from the project's inception, and neglecting risk management can hinder project progress. Project risk encompasses uncertain events that can lead to damage or loss, posing threats to project objectives such as schedule, cost, and quality. Often, project managers have limited information about risks associated with individual activities during the planning phase, which can result in delays and increased costs that affect budgets and quality. Addressing risks correctly is crucial, as not doing so can diminish the effectiveness of risk identification and assessment. The risk response stage typically involves four strategies: risk avoidance, risk transfer, risk reduction, and risk acceptance. These strategies vary based on risk severity, resource availability, and other factors relevant to project managers. Risk avoidance entails eliminating potential risks from the environment, while risk reduction aims to minimize the likelihood of these risks. Implementing risk avoidance may introduce complexities to project management (23).

Furthermore, political issues, shifts in demand, technological advancements, and financial considerations introduce uncertainty into the supply chain (24). Sustainable supply chains and their resilience to disruptions have been examined in numerous studies (25). Managing disruptions involves risk identification, assessment, decision-making, and monitoring (26). Fuzzy logic is a valuable method for addressing uncertainties in supply chain management, enabling more precise statistical and mathematical analyses of complex systems and decisions (27). Fuzzy logic has found applications in a wide array of problems, including newly defined fuzzy post-quantum Bernstein polynomials and extended properties of the Bernstein-Klodowski operators, from real function spaces to fuzzy function spaces (28-30).

The present study seeks to address several significant research gaps within the domain of closed-loop supply chains. Notably, prior models have overlooked the product quality, failed to consider diverse scenarios, omitted capacity constraints in distribution and production centers, neglected the natural impact on CO_2 emissions, and disregarded the vulnerability of critical parameters. This research strives to bridge these gaps by formulating a multi-objective mathematical model that optimizes a sustainable closed-loop supply chain network while factoring in the risk of disruptions in uncertain conditions. To mitigate the risk of disruption in the supply chain network, the study employs sensitivity analysis and numerical tests. By presenting this mathematical model, the research provides a robust decision-making tool for the design and optimization of a sustainable closed-loop supply chain network. In essence, the primary contributions of this research lie in its holistic approach to sustainability considerations and its emphasis on minimizing disruption risk in uncertain conditions. Evaluation of product quality and haulage considerations is incorporated. Various unpredictable scenarios in closed-loop supply chains are accounted for. Capacity constraints in distribution and production centers are considered. Sustainability and resilience in both reverse and direct supply chain flows are explored. The primary objectives include reducing CO_2 emissions, total network costs, and overall risk. Uncertainty in diverse parameters of the mathematical model is addressed.

General limitations of existing models in the field of multi-objective optimization for multi-commodity closed-loop supply chain network with disruption risk is as follow:

- Existing models often simplify the supply chain network by considering only a limited number of factors or assume simplified scenarios. They may not fully capture the complex nature of real-world supply chain systems, including uncertainties, dynamic disruptions, and multiple objectives.
- Many models focus on optimizing a single objective or a predefined set of objectives, which may not be suitable for addressing the dynamic nature of disruptions in a closed-loop supply chain network. These models may not provide robust solutions that can adapt effectively to unforeseen disruptions.
- : While disruption risk is an important factor in closed-loop supply chain network design, existing models may not adequately incorporate probabilistic models or stochastic optimization techniques to handle risks and uncertainties associated with disruptions.
- Some models may focus on a single product or commodity, neglecting the complexities that arise when dealing with a wide range of commodities with different characteristics and requirements within a closed-loop supply chain network.

This paper is structured into five sections. The subsequent section offers an overview of the relevant literature. Section three presents the problem statement and the mathematical model. Next, the paper presents the computational results, and the concluding section wraps up the paper.

2. LITERATURE REVIEW

This section delves into a literature review pertaining to supply chain management, with a specific focus on both reverse and direct supply chains, uncertainty within the supply chain, and sustainability and risk considerations (31, 32). Numerous studies have put forth mathematical models to tackle these challenges. For instance, Pishvaee et al. (33) concentrated on crisis management in a sustainable pharmaceutical supply chain network; while, Khalifehzadeh et al. (34) aimed to minimize costs and maximize system reliability within a four-level supply chain. Zhalechian et al. (35) investigated environmental effects in a location-routing-inventory problem within a sustainable closed-loop supply chain. Rahmani and Mahoodian (36) factored in CO_2 emissions and reliability within their supply chain network design model. Nasr et al. (37) presented a multi-objective fuzzy model that strives to reduce costs, maximize employment opportunities, and incorporate sustainability considerations within the supply chain. Dong et al. (38) put forth a model that takes into account random demand and reproduction systems, with three primary objectives: identifying profitable producers, allocating distributors to customers, and assessing the flow across various supply chain tiers. Diabat and Jebali (13) introduced a multi-period, multi-commodity models that grapples with uncertainty and recovery based on product quality. Wu (39) devised a dynamic competitive game framework, inclusive of government intervention, with the aim of minimizing environmental costs. In contrast, finally, Moradi and Sangari (40) outlined a multi-level supply chain network, accounting for uncertain parameters and employing robust optimization techniques to mitigate fixed and transportation costs. Kalantari et al. (41)employed a fuzzy robust stochastic optimization approach to reduce environmental impacts while maximizing net present value and social impacts within a sustainable closed-loop supply chain. In recent years, several mathematical models have emerged in the field of closed-loop supply chain management. For instance, Salehi-Amiri et al. (42) developed a mixed-integer programming (MIP) model that considers employment-related costs and opportunities in the avocado industry. Kalantari et al. (43) formulated a stable closed-loop supply chain problem with a dual aim of maximizing net present value (NPV) while minimizing carbon emissions, accounting for inherent uncertainties. Garai & Sarkar (44) delved into the realm of independent economic reverse logistics in a customer-centric closed-loop supply chain, focusing on herbal medicines and biotech fuels. Abolghasemian & Darabi (45), Abolghasemian et al. (46) focused on optimization of hauling system of open-pit mine modeling. Additionally, Devika et al. (47) developed a mixed integer programming model multi-objective CLSC problem. Based on built model, three novel hybrid metaheuristic methods are developed which are based on adapted imperialist competitive algorithms and variable neighborhood search. Fatollahi-Fard et al. (48) proposed a dual-channel, multi-product, multi-period, multi-echelon CLSC network design under uncertainty for the tire industry. Ali et al. (49) proposed a comprehensive CLSC network that optimizes environmental, economic, and social footprints through a multi-objective optimization approach. To account for parameter uncertainties, emploied scenario generation using a scenario-based stochastic programming procedure.

Upon reviewing the existing literature and prior research, this study addresses the following research gaps:

1. Failure to incorporate sustainability considerations within supply chain management, often concentrating solely on economic and environmental aspects.
2. Neglect of the diverse scenarios and possibilities that may arise in closed-loop supply chains due to the presence of uncertainty.
3. Overlooking the capacity constraints in supply chain centers and neglecting discussions on handling multiple commodities.
4. Disregarding the significance of product quality as a critical factor in closed-loop supply chain models.
5. Ignoring the element of parameter uncertainty, which can significantly impact the effectiveness of closed-loop supply chain operations.

3. PROPOSED MODEL

3. 1. Problem Definitation

In the scope of this research, a sustainable closed-loop supply chain (CLSC) network is developed, encompassing multiple levels, products, and time periods. The research takes into account the risks associated with returned products within the context of production and distribution-related disruptions in the supply chain. This comprehensive supply chain includes various components, such as markets, collection points, production facilities, distribution centers, suppliers, and recycling and disposal sites. Moreover, different production process levels are identified to facilitate cleaner production processes and minimize manufacturing impacts. Diverse technologies are designed to enable the production of reusable products, reducing the demand for natural resources.

Within this examined supply chain, various disturbances faced by distributors are considered. This includes factors like disruptions caused by issues such as drivers' stress during the distribution process. Additionally, the research delves into the impact of economic sanctions on producers, as these risks can hinder meeting customer demands and disrupt supply chain performance. Factors like outdated technology in industries, unsuitable raw materials, inadequate equipment, and a lack of focus on market requirements can adversely affect the industry in question. Therefore, this study addresses the type of technology utilized in production centers and the costs associated with its use. Consequently, within such a framework, the selection of production and distribution center locations and the establishment of appropriate network flows are deemed of paramount importance. Total supply chain costs encompass facility costs, transportation expenses, procurement, and production costs. Furthermore, the research takes into account the risk stemming from returned products, aligning with a resilience strategy within the reverse supply chain, and considers the social impacts arising from these measures. Given that real-world data required for the mathematical model's parameters are fraught with uncertainties, this research leverages fuzzy set theory to manage these uncertainties. Additionally, to tackle repair-related risks, repair teams are dispatched to designated locations, with the associated repair costs integrated into the supply chain. Lastly, the study examines the supply chain's state under two scenarios: recession and economic boom.

To design a multi-product sustainable CLSC network and create a multi-objective mathematical model that accounts for disruption risks in uncertain conditions, a set of modeling techniques and methods are utilized. These techniques enable the simultaneous pursuit of various objectives, including cost reduction, environmental pollution mitigation resulting from facility creation and product transport, and the enhancement of social welfare within a sustainable multi-product closed-loop supply chain.

To achieve this, a mixed-integer multi-objective mathematical programming model has been formulated. Both deterministic and meta-heuristic methods have been employed to solve the model. The deterministic solution relies on the epsilon-constrained method implemented with GAMS software, while the NSGA-II meta-heuristic solution is executed using MATLAB for the formulation and coding.

The key assumptions underlying the model are as follows:

- Fuzzy demand is considered to accommodate real-world uncertainties.
- Uncertainty in the quality factor of returned products is accounted for.
- The model is multi-period, multi-product, and multi-objective in nature.
- Facility location is assumed to be fixed, and the model selects these locations from among all potential alternatives.

The cost of goods and product transportation between centers is treated as fixed within each scenario. The structural representation of the proposed model is depicted in Figure 1, which is illustrating the cycle pertaining to the CLSC examined in this research. According to this cycle, products produced are distributed to customers through various distributors. Some of these sold products are returned, refurbished, and reutilized, while others may be discarded as waste or reintroduced into the production cycle as recycled products.

3. 2. Notation In this section, all the symbols used to describe sets, parameters, and variables of the problem are explained in Tables 1-3.

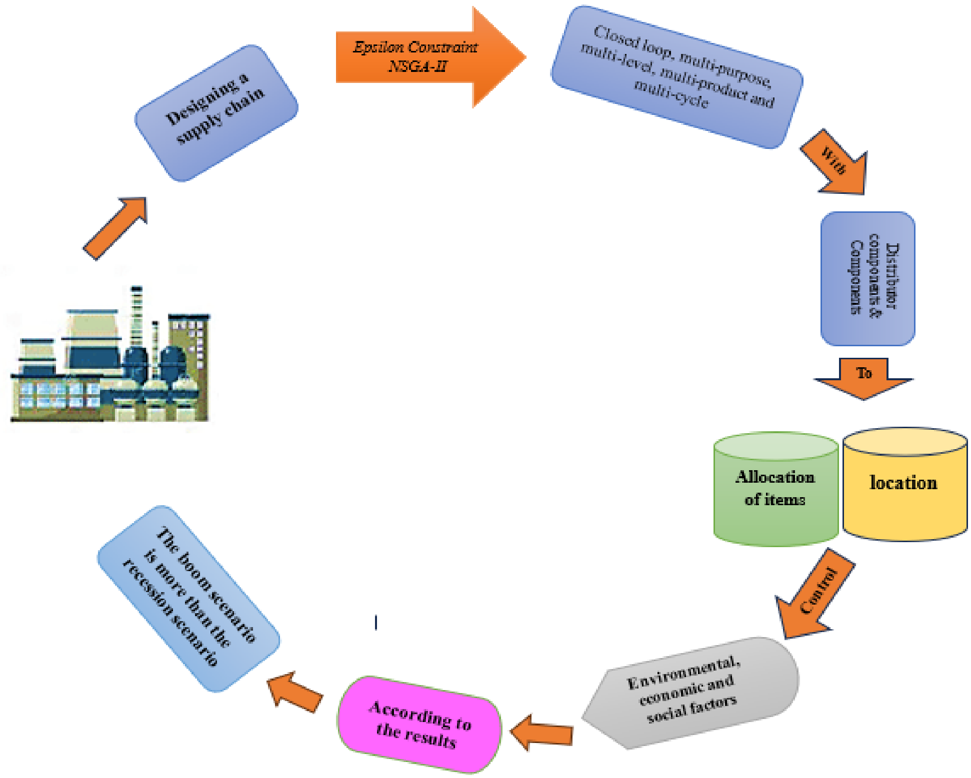

Figure 1. The structure of proposed model

TABLE 1. Notation for indices in the Mathematical Model

Indices	
Symbol	**Explanation**
K	The set of customers $\boldsymbol{k} \in \{1, 2, 3\}$
R	The set of re-use centers $\boldsymbol{r} \in \{1, 2\}$
J	The set of distributors $\boldsymbol{j} \in \{1, 2\}$
P	The set of products $\boldsymbol{p} \in \{1, 2\}$
I	The set of collection centers $\boldsymbol{i} \in \{1, 2, 3\}$
W	The set of burial and disposal sites $\boldsymbol{w} \in \{1\}$
Y	The set of suppliers $\boldsymbol{y} \in \{1, 2\}$
H	The set of manufacturers $\boldsymbol{h} \in \{1, 2\}$

TABLE 2. Notation for parameters in the Mathematical Model

li_y	Center y's volume capability
li'_{hv}	Center h's ability to revamp products using technology v
li_w	Capacity of establishment w
li_{hv}	Center h's capacity to utilize technology v
li_i	Maximum potential of center i
li_r	Capability of center r
li_j	Capacity of establishment j
cb_w	Center w's carbon footprint
cb_i	CO2 emissions from center i's operations
cb_r	The amount of CO2 emitted by center r
cb_j	Carbon emissions associated with center j
cpk	Emissions resulting from delivering one unit of product per distance unit
h_w	Establishment costs of center w
h_p	Center p's fixed establishment cost
h_i	The initial expense of setting up center i
h_j	Fixed start-up cost for center j

$\boldsymbol{vl_{ps}}$	Quantity of product p in scenario s following recycling
$\widetilde{\boldsymbol{d_{ks}^{pt}}}$	Customer demand for product p in period t from segment k in scenario s
$\boldsymbol{fo_{ps}}$	Unit production cost of product p under scenario s
$\boldsymbol{f'o_{ps}}$	The expense of collecting one unit of product p in scenario s
$\boldsymbol{pg^{s}_{pq}}$	The price of returned product p with quality q in scenario s
$\boldsymbol{d_{ihvqs}^{p}}$	Transportation distance/cost of delivering product p with quality q from center i to center h using technology v in scenario s
$\boldsymbol{d_{yhs}^{p}}$	Shipping costs/distance for product p from center y to center h in scenario s
$\boldsymbol{d_{hjs}^{p}}$	Transporting product p from center h to center j, including distance and cost, in scenario s
$\boldsymbol{d_{kis}^{p}}$	Transportation costs/distance for delivering product p from customer k to center i in scenario s
$\boldsymbol{d_{irqs}^{p}}$	Shipping expenses/distance for delivering product p from center i to center r with quality q in scenario s
$\boldsymbol{d_{iwqs}^{p}}$	Distance/travel cost for transporting product p from center i to center w with quality q in scenario s
$\boldsymbol{d_{rhqs}^{p}}$	Shipping costs/distance for delivering product p from center r to center h with quality q in scenario s
$\boldsymbol{d_{jks}^{p}}$	Distance/cost of product transportation from center to customer in scenario s
$\boldsymbol{pr_{s}}$	Probability of occurrence for scenario s
$\boldsymbol{r_{k,q,s}^{pt}}$	Return rate of product p with quality q from customer site k during period t in scenario s
$\boldsymbol{rr'^{pt}}$	Return rate of product p from collection center to burial site during period t
$\boldsymbol{rr^{pt}}$	Return rate of product p from collection center to the manufacturer during period t
$\boldsymbol{rr''^{pt}}$	Return rate of product p from collection center to recycling center during period t
$\boldsymbol{pol_{jt}}$	Total pollution emitted during establishment of center j in period t
$\boldsymbol{pol_{it}}$	Total pollution emitted during establishment of center i in period t
$\boldsymbol{pol_{rt}}$	Total pollution emitted during establishment of center r in period t
$\boldsymbol{pol_{wt}}$	Total pollution emitted during establishment of center w in period t
$\boldsymbol{\alpha_{hts}}$	1 if there is no disruption in production center h during period t in scenario s, otherwise 0
$\boldsymbol{\beta_{yts}}$	1 if there is no disruption in supply center y during period t in scenario s, otherwise 0
$\boldsymbol{cm_{hts}}$	Repair cost of manufacturing center h during period t in scenario s
$\boldsymbol{cm_{yts}}$	Repair cost of supply center y during period t in scenario s

TABLE 3. Notation for Variables of the Mathematical Model.

$\boldsymbol{x_{j}}$	If center d is formed, it will be assigned a value of 1; otherwise, it will be assigned a value of 0.
$\boldsymbol{x_{i}}$	In the event that center g is established, its assigned value will be 1; if not, its value will be 0.
$\boldsymbol{x_{r}}$	Center b will have a value of 1 if it is established; otherwise, it will have a value of 0.
$\boldsymbol{x_{w}}$	Should center e be established, its value will be 1; otherwise, it will be 0.
$\boldsymbol{z_{ihvqs}^{pt}}$	Number of product p sent from center i to center h by technology v with quality q during period t in scenario s
$\boldsymbol{z_{hvjs}^{pt}}$	Number of product p sent from center h to center j by technology v during period t in scenario s
$\boldsymbol{z_{jks}^{pt}}$	Number of product p sent from center j to customer k during period t in scenario s
$\boldsymbol{z_{rhqs}^{pt}}$	Number of product p sent from customer j to center k with quality q during period t in scenario s
$\boldsymbol{z_{iwqs}^{pt}}$	Number of product p sent from center j to center w with quality q during period t in scenario s
$\boldsymbol{z_{yhs}^{pt}}$	Number of product p sent from center y to center h during period t in scenario s
$\boldsymbol{z_{irqs}^{pt}}$	Number of product p sent from center i to center r with quality q during period t in scenario s
$\boldsymbol{y_{ht}}$	If repair group f is sent to center h during period t, it's 1
$\boldsymbol{y_{yt}}$	If repair group f is sent to center y during period t, it's 1

3. 3. Model Formulation

In this section, all equation used to describe mathematical modeling, are explained.

$$Min\ f_1 = (\sum_{j\in J} h_j x_j + \sum_{i\in I} h_i x_i + \sum_{r\in R} h_r x_r + \sum_{w\in W} h_w x_w) + pr_s(\sum_t \sum_s(\sum_{p\in P} \sum_{y\in Y} \sum_{h\in H} \beta_{hts}.\, d_{yhs}^{p} z_{yhs}^{pt} + \sum_{p\in P} \sum_{y\in Y} \sum_{j\in J} mdx_{jks}^{st} + \sum_{p\in P} \sum_{j\in J} \sum_{k\in K} d_{jk,s}^{p} z_{jks}^{pt} + \sum_{h\in H} \sum_{s\in S} \sum_{t\in T} y_{ht}.\, cm_{hts} + \sum_{y\in Y} \sum_{s\in S} \sum_{t\in T} y_{yt}.\, cm_{yts} \tag{1}$$

$$Min\ f_2 = \sum_{r\in R} x_r.\ cb_r + \sum_{i\in I} x_i.\ cb_i + \sum_{w\in W} x_W.\ cb_w + \sum_{j\in J} x_j.\ cb_j + \sum_{s\in S} w_{sen}.\sum_{t\in T} CEM\, [\sum_t \sum_s(\sum_{p\in P} \sum_{y\in Y} \sum_{h\in H} d_{yhs}^{p} z_{yhs}^{pt} + \sum_{p\in P} \sum_{y\in Y} \sum_{j\in J} mdx_{jks}^{st} + \sum_{p\in P} \sum_{j\in J} \sum_{k\in K} d_{jk,s}^{p} z_{jks}^{pt} + \sum_{s\in S} \ (\sum_{p\in P} \sum_{k\in K} \sum_{h\in H} d_{kis}^{p} z_{kis}^{pt} + \sum_{p\in C} \sum_{q\in Q} \sum_{i\in I} \sum_{r\in R} d_{irqs}^{p} z_{irqs}^{pt} + \sum_{p\in P} \sum_{q\in Q} \sum_{i\in I} \sum_{w\in W} d_{iwqs}^{p} z_{iwqs}^{pt} + \sum_{v\in V} \sum_{p\in P} \sum_{q\in Q} \sum_{i\in I} \sum_{h\in H} d_{ihqs}^{c} z_{ihvqs}^{ct} + \sum_{p\in P} \sum_{q\in Q} \sum_{r\in R} \sum_{h\in H} d_{rhqs}^{p}\, z_{rhqs}^{pt})] \tag{2}$$

$$Minf3 = \sum_{t\in T} \sum_{j\in J} pol_{jt}. x_j\ + \sum_{i\in I} \sum_{t\in T} pol_{it}\ . x_i + \sum_{r\in R} \sum_{t\in T} pol_{rt}\, . x_r + \sum_{w\in W} \sum_{t\in T} pol_{wt}. x_w \tag{3}$$

Subject to:

$$\sum_{w\in W} x_w \geq 1 \tag{4}$$

$$\sum_{i\in I} x_i \geq 1 \tag{5}$$

$$\sum_{j\in J} x_j \geq 1 \tag{6}$$

$$\sum_{r\in R} x_r \geq 1 \tag{7}$$

$$\sum_{q_2} \sum_{y\in Y} z_{irqs}^{pt} = rr^{pt} \sum_q \left(\sum_{k\in K} z_{kiqs}^{pt}\right) \quad \forall i \in I, p \in P, t \in T, s \in S \tag{8}$$

$$\sum_{i\in I} z_{kiqs}^{pt} = r_{kqs}^{p} . \sum_{p\in P} \sum_{k\in K} z_{jks}^{pt} \quad \forall k \in K, j \in J, t \in T, q \in Q, s \in S \tag{9}$$

$$\sum_{q1} \sum_{h\in H} \alpha_{hts} . z_{ihvqs}^{pt} = rr^{pt} \sum_q \left(\sum_{k\in K} z_{kiqs}^{pt}\right) \quad \forall i \in I, v \in V, p \in P, t \in T, s \in S \tag{10}$$

$$\sum_{h\in H} \left(\alpha_{hts} . z_{hvjs}^{pt} + w_{hjs}^{pt}\right) = \sum_{l\in L} z_{jks}^{pt} \quad \forall j \in J, v \in V, p \in P, t \in T, s \in S \tag{11}$$

$$\sum_{q2} \sum_{w\in W} z_{iwqs}^{pt} = rr^{pt} \sum_q \left(\sum_{k\in K} z_{kiqs}^{pt}\right) \quad \forall p \in P, t \in T, i \in \mathrm{I}, s \in S \tag{12}$$

$$\sum_{q_2} \sum_{i\in I} z_{irqs}^{pt} = \sum_q \sum_{h\in H} z_{rhqs}^{pt} \quad \forall r \in R, p \in P, t \in T, s \in S \tag{13}$$

$$\sum_{q_1} \sum_{h\in H} \alpha_{hts} . z_{ihvqs}^{pt} + \sum_{q_2} \sum_{r\in R} z_{irqs}^{pt} + \sum_{q_3} \sum_{w\in W} z_{iwqs}^{pt} = \sum_q \sum_{k\in K} z_{kiqs}^{pt} \tag{14}$$

$$\sum_{y\in Y} z_{yhs}^{pt} + \sum_{q_1} \sum_{i\in I} \alpha_{hts} . z_{ihvqs}^{pt} + \sum_{q\in Q} \sum_{r\in R} z_{rhqs}^{pt} = \sum_{j\in J} \alpha_{hts} . z_{hvjs}^{pt} \quad \forall h \in H, v \in V, p \in P, t \in T, s \in S \tag{15}$$

$$rr^{pt} + rr^{pt} + rr^{pt} = 1 \quad \forall p \in P, t \in T \tag{16}$$

$$\sum_{j\in J} z_{jks}^{pt} \geq d_{ks}^{pt} \quad \forall k \in K, p \in P, t \in T, s \in S \tag{17}$$

$$\sum_{p\in P} \sum_{h\in H} z_{yhs}^{pt} \leq li_y \quad \forall y \in Y, t \in T, s \in S \tag{18}$$

$$\sum_{p\in P} \sum_{j\in J} z_{hvjs}^{ct} \leq li_{hv} \quad \forall h \in H, v \in V, t \in T, s \in S \tag{19}$$

$$\sum_{p\in P} \sum_{k\in K} z_{jks}^{pt} \leq li_j x_j \quad \forall j \in J, t \in T, s \in S \tag{20}$$

$$\sum_{q_3} \sum_{p\in P} \sum_{i\in I} z_{iwqs}^{pt} \leq li_w x_w \quad \forall w \in W, t \in T, s \in S \tag{21}$$

$$\sum_{p\in P} \left(\sum_{q_1} \sum_{i\in I} \alpha_{hts} . z_{ihvqs}^{pt} + \sum_q \sum_{r\in R} z_{rmqs}^{pt}\right) \leq li_{hv} \quad \forall h \in H, v \in V, t \in T, s \in S \tag{22}$$

$$\sum_{qs_2} \sum_{p\in P} \sum_{i\in I} z_{irqs}^{pt} \leq li_r x_r \quad \forall r \in R, t \in T, s \in S \tag{23}$$

$$\sum_{q_1} \sum_{p\in P} \sum_{i\in I} \alpha_{hts} . z_{ihvqs}^{ct} + \sum_{q_3} \sum_{p\in P} \sum_{w\in W} z_{iwqs}^{pt} + \sum_{q_2} \sum_{p\in P} \sum_{r\in R} z_{irqs}^{pt} \leq li_r x_r \quad \forall i \in I, v \in V, t \in T, s \in S \tag{24}$$

$$1 - \alpha_{hts} \leq y_{ht} \quad \forall h \in H, t \in T, s \in S \tag{25}$$

$$1 - \beta_{yts} \leq y_{yt} \quad \forall y \in Y, t \in T, s \in S \tag{26}$$

$$z_{ihvqs}^{pt}, z_{hvjs}^{pt}, z_{jks}^{pt}, z_{rhqs}^{pt}, z_{kiqs}^{pt}, z_{iwqs}^{pt}, z_{yhs}^{pt}, z_{irqs}^{pt} \geq 0 \tag{27}$$

$$x_j, x_i, x_r, x_w, y_{ht}, y_{yt} \in \{1,0\} \quad \forall j \in J, i \in I, r \in R, w \in W \tag{28}$$

The objective Function 1 in the above model minimizes the cost of the entire supply chain, which is related to the construction, flow of goods, transportation, return of returned products, burial, collection and production. The objective Function 2 reduce the amount of CO_2 gas emitted from newly established centers and product transportation equipment. The objective Function 3 reduce the occurrence of risks. By considering the above three functions in this research, the highest social level is achieved. Constraint 4 ensures that there is at least one place to bury waste products. Constraint 5 guarantees that there is a center for the collection of return products identified by the model. Constraint 6 guarantees that there is at least one center for the distribution of goods. Constraint 7 guarantees that there is at least one recycling center for the returned products to be recycled. Constraint 8 ensures that there is an equilibrium between collection and recycling centers. Limitation 9 guarantees that no return products are left before customers and are completely collected. Limitation 11 shows the amount of goods sent to customers. Limitation 12 shows the balance between the place of collection and burial of reversible products. Limitation 13 guarantees balance at the recycling node. Limitation 14 guarantees the quantity of goods sent to collection centers from customers. Limitation 15 guarantees the quantity of goods sent to distributors from manufacturers. Limitation 16 guarantees that the sum of the coefficients of the returned products is equal to 1. Limitation 17 guarantees that the demand must be fully satisfied. Limitation 18 guarantees that the capacity of suppliers is not exceeded. Limitation 19 guarantees not to exceed the capacity of constructors. Limitation 20 shows not exceeding the capacity of distributors. Limitation 21 shows that burial centers must be used if they are created. Limitation 22 shows the capacity of production centers to reproduce products. Limitation 23 guarantees that recycling centers are used. Limitation 24 shows the number of collection centers. It can also be used if a collection center is created. Limitation 25 and 26 indicate that if a center breaks down, it must be rebuilt by the repair group. Limitations 27 and 28 indicate the type of decision variables.

3. 4. Proposed Fuzzy Model This research the fuzzify the model is used. A triangular fuzzy approach is employed concerning the existing uncertainty in demand, establishment costs of centers, and CO_2 emissions from established centers. The definition of these uncertain parameters are as follows:

$\widetilde{(\mathbf{j_1}, \mathbf{j_2}, \mathbf{j_3})}_{\mathbf{is}}{}^{\mathbf{pt}}$	The imprecise product p demand from customer i during period t in scenario s
$\widetilde{(\mathbf{h_1}, \mathbf{h_2}, \mathbf{h_3})}_{\mathbf{j}}$	The vague cost of creating center j
$\widetilde{(\mathbf{h_1}, \mathbf{h_2}, \mathbf{h_3})}_{\mathbf{p}}$	The uncertain expenses for setting up center p
$\widetilde{(\mathbf{h_1}, \mathbf{h_2}, \mathbf{h_3})}_{\mathbf{i}}$	The ambiguous costs associated with establishing center i
$\widetilde{(\mathbf{h_1}, \mathbf{h_2}, \mathbf{h_3})}_{\mathbf{w}}$	The imprecise cost of creating center w
$\widetilde{(\mathbf{cb_1}, \mathbf{cb_2}, \mathbf{cb_3})}_{\mathbf{j}}$	The uncertain quantity of CO_2 emitted during the establishment of center j
$\widetilde{(\mathbf{cb_1}, \mathbf{cb_2}, \mathbf{cb_3})}_{\mathbf{p}}$	The ambiguous amount of CO_2 released when setting up center p
$\widetilde{(\mathbf{cb_1}, \mathbf{cb_2}, \mathbf{cb_3})}_{\mathbf{i}}$	The vague emissions associated with establishing center i
$\widetilde{(\mathbf{cb_1}, \mathbf{cb_2}, \mathbf{cb_3})}_{\mathbf{w}}$	The fuzzy environmental impact of creating center w

Let's say we want to solve a linear mathematical model using classical methods. We can do this by following these steps:

$$\text{Max } C^t x$$
$$\text{Subject to:} \tag{29}$$
$$A_i x \le b_i, \;\; x \ge 0, \;\; (i = 1, \dots, m)$$

The values of A, b, and c are fixed in this context. To convert a fuzzy limitation into a clear membership function, the proposed approach is employed. Tan and Cao present a linear normal fuzzy model by defining the objective function in the following manner:

$$\text{LP }(\alpha)$$
$$Max C^t x$$
$$\text{Subject to:} \tag{30}$$
$$A_i x \le b_i + (1-\alpha) p_i, \quad i = 1,2,\dots,m, \quad x \ge 0, \quad \alpha \in [0,1]$$

The optimization problem involves a parameter α that takes values between 0 and 1. The linear-term coefficient $pi \ge 0$ is non-negative, whileLP_α, B_α and z_α denote the optimal value, vector, and solution of the equation LP_α respectively. The right coefficient $b + (1-\alpha)p$ varies depending on the chosen α, and P0 represents the difference between the optimal and secondary vectors. To implement the proposed algorithm, one selects z_1 and z_0 as the optimal values of $LP_1$and LP_0, respectively, subject to the condition $p_0 = z_0 - z_1 > 0$.

4. PROPOSED SOLUTION ALGORITHM

4. 1. ϵ −Constraint Method One of the popular methods in multi-objective optimization, which will be used in this research, is the $\boldsymbol{\epsilon}$ −constraint method, in which one of the objective functions is selected for optimization, and other objective functions become constraints with an upper limit of ε (6, 46, 47). In the epsilon method, the limitation is that one of the contradictory goals is kept in the objective function and other functions are limited by defining an upper bound.

In fact, in this way, the multi-objective problem becomes a single-objective problem. The limit of the objective functions for the problem is such that by changing the vector on the right side of the problem, all possible Pareto solutions for the multi-objective problem are repeated from the upper limit to the lower limit, and the problem is solved. Then, an optimal solution for the problem is produced. By changing the epsilons, we can get different values for the main objective function. All possible Pareto solutions for the multi-objective problem are generated. The general form of the $\boldsymbol{\epsilon}$-constraint problem is as follows.

$$\begin{aligned} &\max f_i(x) \\ &s.t \\ &f_j(x) \le \epsilon_i \quad \forall i \ne j \\ &x \in X \end{aligned} \tag{31}$$

4. 2. NSGA-II Based on the genetic algorithm that is in accordance with the natural property of reproduction, first a potential population P is considered as a productive population. Therefore, the community is sorted based on this sorting algorithm and a Pareto rank is assigned to each individual. At this stage, various optimization problems become a Pareto optimization problem. For this purpose, the mutation and crossover operators to create the resulting number of children are specified using the Q and N sets. Next, a mixed population is created by assigning each child to one parent. Finally, the combined population is sorted and the N best individuals are considered as the population for the next generation.

4. 2. 1. Solution Reprisentation In Figure 2, the rows and columns represent manufacturers and suppliers and the duration of repairs, respectively. The numbers of each cell also guarantee the dispatch or non-dispatch of the work service to the place.

For the crossover operation, the suitable parents for each child must first be selected from the generated population, for this purpose, the Roulette cycle structure is used. Based on this, the selection criterion is based on solutions that have a greater density distance.

	t_1	t_2	t_3	t_1	t_2	t_3
m_1	1	1	0	0	0	1
m_2	0	0	1	1	0	1
n_1	1	1	0	1	0	1
n_2	0	1	1	1	1	0

Figure 2. Chromosome representation

4. 2. 2. Crossover and Mutation Operators The crossover operation is performed point by point for location variables. This location selection structure leads to the creation of convergent solutions for the problem based on the algorithm. In this study, creating two points for chromosome selection is used for crossover operation (49-52).

For the mutation operation, a chromosome is randomly selected. Because, the random selection of chromosomes increases the variety of solutions and presents different situations. In this research, a set of chromosomes are randomly selected, but they are used for reverse mutation operations (Figure 3).

Setting the parameters used in this study is reported based on Taguchi approach stated in Tables 4 and 5.

Then, according to Taguchi L9 design, the following NSGA-II algorithm is implemented. After entering data in MINITAB software and implementing Taguchi method, the S / N diagram is presented in Figure 4.

4. 2. 3. Full Algorithm There are deference methods to analyze the efficiency of genetic algorithm. For example, one of these indicators is the average distance from the average ideal distance (MID) metric. This index is calculated using equation 32. In equation 35, n is equal to the number of Pareto points, and $f_{1,total}^{max}$ and $f_{1,total}^{min}$ are the highest and lowest values of the objective function in the algorithm.

Parent

81	54	46	62	71	48
6	61	28	95	401	100
47	44	57	401	461	75
100	321	32	63	123	91

Child

81	54	46	62	71	47
100	401	95	28	61	6
47	44	57	401	461	75
100	321	32	63	123	91

Figure 3. Mutation operator

TABLE 4. Parameters and their value levels for the NSGA-II algorithm

Parameters	Values of each level		
	Level 1	Level 2	Level 3
Rate of Crossover (RC)	0.5	0.6	0.7
Rate of Mutation (Rm)	0.4	0.5	0.6
Number of potential in the Population (N-pop)	50	100	150
Maximum iteration (Max-iteration)	50	150	200

TABLE 5. Tuning the parameters

Parameters	Description	Value
nPop	Population number	150
MaxIt	Iteration number	80
Rc	Cross over rate	0.6
Rm	Mutation rate	0.5

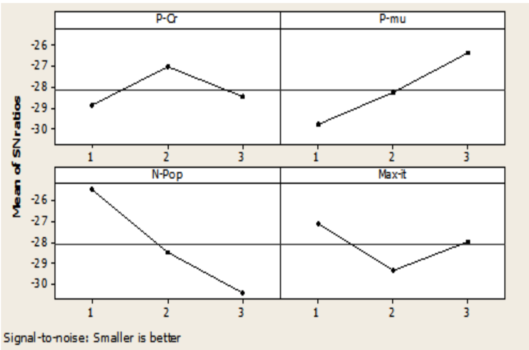

Figure 4. Output of Taguchi method in NSGA-II algorithm

$$MID = \frac{\sum_{i=1}^{n} \sqrt{\left(\frac{f_{1i}-f_1^{best}}{f_{1,total}^{max}-f_{1,total}^{min}}\right)^2+\left(\frac{f_{2i}-f_2^{best}}{f_{2,toal}^{max}-f_{2,total}^{min}}\right)^2}}{n} \quad (32)$$

where the ideal point's coordinates are (f_1^{best}, f_2^{best}).

5. COMPUTATIONAL RESULTS

5. 1. Simulated Instances

In this part of the research, the results of the mathematical model are presented to measure the efficiency of the model. In Table 6, numerical examples are considered in different dimensions. For this purpose, 10 problems have been considered as examples, which are numerical problems 1-4 on a small scale, numerical problems 5-7 on a medium scale, and numerical examples 8-10 on a large scale, respectively.

Table 7 shows the findings of solving the model in small, medium and large dimensions. The solved results have been solved based on classification of problem dimensions; also, based on the epsilon constraint method and genetic meta-heuristic method. According to the obtained results, the problem-solving time using the epsilon constraint method increases, while the solving time using the genetic meta-heuristic method is less than the deterministic ϵconstraint method. In addition, the deterministic ϵconstraint method is not able to solve the problem in large scales, but considering that the calculation error between the meta-heuristic method and the deterministic method in the first and third objective function is less than 1% and in the second objective function less than 6%. It is possible to use the results of meta-heuristic method in large dimensions instead of exact solution to solve problems. Therefore, considering that the calculation error between the epsilon constraint method and NSGA-II is less than 0.1 in the 95% confidence interval; therefore, we can conclude that from the meta-heuristic method in the long run and in very large problems that the epsilon limit method is able to handle it. We should not use it to solve and estimate the value of the objective function.

Table 8 presents the results of the implementation of the evaluation criteria to measure the performance of the NSGA-II approach. According to the obtained results, the standard average of MID is equal to 6.56. Therefore, the results obtained from the proposed solution method can be trusted to solve large-scale problems.

TABLE 6. Various scales examples

Scale	Examples	Disposal centers	Collection centers	Manufacturers	Recycling centers	Customers	Distribution centers	Supplier
Small Scale	Example 1	1	2	1	1	1	2	1
	Example 2	2	1	1	1	1	2	2
	Example 3	2	2	2	2	2	2	3
	Example 4	3	2	3	3	2	2	3
Medium Scale	Example 5	3	2	3	4	2	3	3
	Example 6	3	3	4	4	3	3	4
	Example 7	4	3	4	4	3	3	4
Large Scale	Example 8	4	4	4	4	3	4	4
	Example 9	5	5	5	4	3	4	5
	Example 10	6	6	5	5	4	5	6

TABLE 7. Comparison between finding for exact and meta-heuristic method

Error%			**NSGA-II**				**Epsilon constraint**				**No**
f_3	f_2	f_1	**Time(s)**	f_3	f_2	f_1	**Time(s)**	f_3	f_2	f_1	
0.001	0.05	0.009	1.01	3.46	225.3	631	1.11	3.11	213.6	625	1
0.004	0.03	0.008	3.6	4.77	364.1	674	25.69	4.58	358.3	661	2
0.009	0.04	0.007	5.14	5.39	371.5	697	36.14	5.17	365.3	684	3
0.008	0.05	0.007	12.17	6.14	382.1	702	84.74	5.98	371.8	689	4
0.008	0.04	0.006	22.17	6.25	621.7	1022	657.11	6.10	583.9	978	5
0.009	0.03	0.005	33.69	7.94	647.5	1125	974.12	7.87	614.9	1058	6
0.008	0.05	0.005	37.17	8.07	751.6	1361	1473.8	7.93	728.3	1236	7
0.007	0.05	0.004	42.57	8.66	911.6	1911	1971.7	8.47	892.4	1894	8
0.005	0.04	0.002	56.33	9.11	1162.4	2230	2037.11	8.98	1034.1	2068	9
0.002	0.02	0.002	61.28	9.68	1319.7	2487	2975.64	9.51	1298.7	2540	10

TABLE 8. Performance evaluation standards

MID	0	6.13	6.16	6.32	6.51	6.59	6.65	6.76	6.81

Figures 5 and 6 show the solution time for small, medium, and large-scale problems. As observed, the solution time of the Epsilon constraint method increases at a higher level than in the NSGA-II method. In contrast, in the NSGA-II method, increase in solution time is the more stable level.

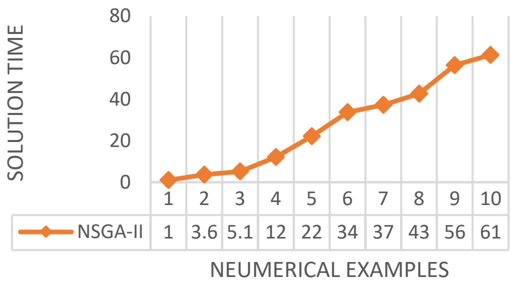

Figure 5. Solution time in NSGA-II method

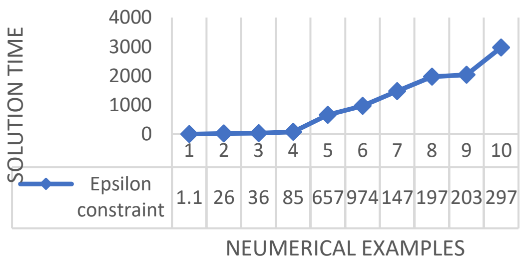

Figure 6. Solution time in Epsilon constraint method

5. 2. Calibration Analysis This research has been implemented as a pilot in the plastic industry, including five suppliers, five types of product variety, four distributors, five collection centers and 10 major customers. As an output from this chain, plastic nylon reaches customers after collecting the raw materials. Then, the gathering waste and classified as scrap materials based on their quality from customers. Some of these wastes are buried and the rest are recycled for reproduction. In this study, based on the defined goals, we intend to reduce the environmental effects emanating from them in order to improve the social effects. Table 9 depict the numerical finding of applying the mathematical model in the real study. According to Table 9, the amount of product supply flow to production centers is shown based on recession and boom scenarios in each time period. The first scenario is considered as a boom scenario and the second scenario as a recession scenario. Based on the obtained results, the shipment flow from supply center number 1 to production center 1 according to the recession scenario is equal to 98 and 124 during two periods. This is despite the fact that according to the boom scenario, this flow transfer is equal to 124 and 395.

5. 3. Sensitivity Analysis In this part of the research, we make changes in the basic parameters of the model to assess the effect of changing the parameters on the value of the objective function. Figure 7 shows the number of centers for building recycling centers with increasing demand. Because, the increase in the amount of demand makes more recycling centers to be built. This issue is much more when we are facing a recession scenario. For example, if demand increases by 5%, the number of recycling centers that can be established increases from one to three.

TABLE 9. The product flows from supplier center to producer centers

Producer and supplier \ Type/ Cycle	Type 2-Cycle2	Type2-Cycle1	Type1-Cycle2	Type1-Cycle1
Supplier1 – Producer 1	98	124	124	365
Supplier1 – Producer 3	258	279	419	478
Supplier2- Producer 2	457	364	574	578
Supplier2- Producer 4	689	398	916	574
Supplier3- Producer 1	367	405	589	368
Supplier3 – Producer 4	714	458	1287	475
Supplier4 – Producer 3	513	517	873	366
Supplier4 – Producer 4	657	598	987	314
Supplier5 – Producer 2	698	687	573	755
Supplier5 – Producer 5	547	697	429	719

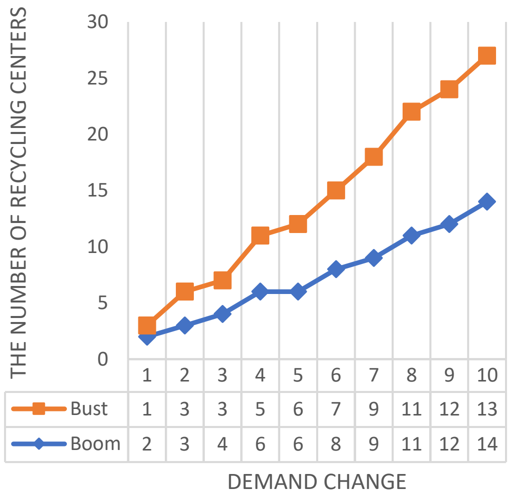

Figure 7. Changing demand and its effect to the costs

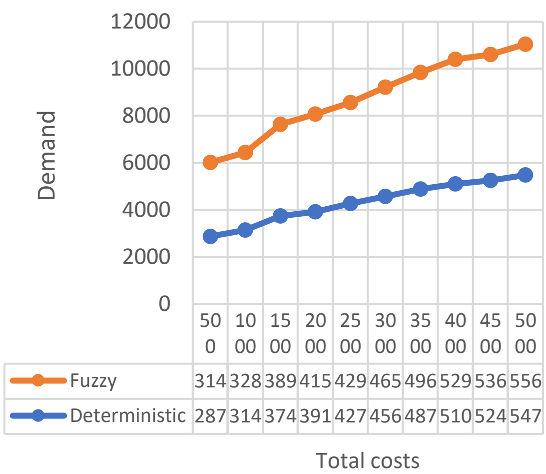

Figure 8. The effect of demand's change on costs in deterministic and fuzzy models

Figure 8 shows that the total costs vary based on demand changes in two deterministic and fuzzy model cases. As observed, the increase in demand raises the total costs in two cases. The amount of costs in an uncertain situation is higher than that in a deterministic situation. Also, the increase in costs by increasing the demand is higher in a fuzzy environment rather than in a deterministic environment.

5. 4. Discussion and Managerial Insights According to the numerical findings obtained in this research, the suggested model has been solved using two methods, epsilon, constraint and genetics. The duration of solving the model using the epsilon method is more limited than the meta-heuristic method. Moreover, the calculation error between the limit epsilon method and the meta-heuristic algorithm in small and medium dimensions for the first and third objective function is less than 1% and for the third objective function is less than 6%, which can be a proof of the reliability of the meta-heuristic algorithm in large dimensions are the limit for solving the problem instead of the epsilon method. In addition, in the meta-heuristic method, the standard mean of MID is equal to 6.56. Based on the obtained results, the shipment flow from supply center number 1 to production center 1 according to the recession scenario is equal to 98 and 124 during two periods. This is despite the fact that according to the boom scenario, this flow transfer is equal to 124 and 395. As observed, the increase in demand raises the total costs in two cases of deterministic and fuzzy models. The amount of costs in an uncertain situation is higher than that in a deterministic situation. Also, the increase in costs by increasing the demand is higher in a fuzzy environment rather than in a deterministic environment. According to above mentioned building a multi-objective mathematical model of a multi-product sustainable CLSC network, taking into account the risk of disruption in the conditions of uncertainty, is one of the complex and challenging issues in the field of SCM. In this context, the most important managerial insights are:

1. Productivity: Gain more productivity in using resources in real time.
2. Flexibility: designing a system that can adapt to different conditions.
3. Sustainability: planning and implementing activities in a way that indicates financial, environmental, social and process sustainability.
4. Optimism: obtaining the most optimal solution for the balance between cost and performance, improving internal and external processes of the organization.
5. Risk management: identifying, measuring and controlling risks, taking into account uncertainty and environmental changes.
6. Cooperation: providing cooperation and coordination between employees, departments and business partners.
7. Strategizing: designing appropriate strategies to maintain and develop the organization's competitive ability.
8. Energy efficiency: Economizing the use of energy in the SC in a way that leads to cost reduction and environmental protection.
9. Technology: Using new technologies in various fields such as tag identification, IoT and goods circulation to improve the performance and sustainability of the SC.
10. Transparency: ensuring transparency in processes and information to increase the trust of customers and business partners.

5. CONCLUSION AND FUTURE STUDIES

In modern business, the ability to differentiate key competencies has become critical for companies' competitiveness. To achieve this, companies often focus on their strengths and seek to improve sustainability to gain a competitive advantage. The innovative aspects of this study include considering product quality, vulnerability scenarios, production and distribution capacity, and sustainability in the supply chain. The problem was solved using the Epsilon Constraint and NSGA-II methods on small, medium, and large scales. The results showed that costs increase as demand increases, especially during boom cycles. The number of built-up centers also increases with demand, particularly during boom cycles. Additionally, the study compared deterministic and fuzzy models, and emphasized the importance of considering returned goods as valuable assets in the CLSC. Also, the resilience of the designed network was viewed by this assumption that facilities may fail in the SC, and the disruption risk is removed. In addition, in this study, we developed the mathematical model for a cleaner production process and minimizing possible environmental and human health damage. The suggested model tries to reduce the SC costs and environmental effects. Main obtained results of the research is as follow:

- The model was solved on various dimension using the ε-Constraint and NSGA-II algorithm.
- Also, using a case study, Sunny Plats Industries, the validity of the model was investigated.
- MID ration calculates 6.48 for NSGA-II.
- In addition, according to the numerical results, the flow in the Boom Scenario is more than that in the Bust Scenario.
- By increasing the demand, the number of established centers gets higher.

In the research design a mathematical model of the multi-product sustainable CLSC network, taking into account the risk of disruption in the conditions of uncertainty, there are important limitations that should be considered. Some of the most important research limitations are:

1. Time limit: There is a limited time for data collection and mathematical model design. This limitation can put a lot of pressure on the researcher due to the scarcity of resources.

2. Data limitation: It may be difficult to collect enough data to cover all possible conditions in a state of uncertainty.

3. Mathematical limitation: Mathematical methods for modeling the multi-product sustainable CLSC network considering the risk of disruption in conditions of uncertainty are very complex and time-consuming.

4. Communication limitation: In designing a mathematical model, there is a need for coordination between real people, which can be a limitation due to geographical distance, time and cost.

5. Resource limitation: To design a mathematical model, there is a need to access various resources, including powerful computers and specialized software to solve mathematical problems. This limitation may cause the cost of model design to increase dramatically.

This study primarily used the epsilon constraint and NSGA-II methods for the decision problem under study. For future research, the authors suggest using more advanced optimization algorithms for this decision problem. Therefore, it is proposed to develop a general discussion on the importance of advanced optimization algorithms (eg, hybrid heuristics and meta-heuristics, adaptive algorithms, self-adaptive algorithms, island algorithms, polyploid algorithms, hyper-heuristics) for challenging decision problems. For this purpose, there are various fields in which advanced optimization algorithms are used as solution approaches, such as machine learning, scheduling, multi-objective optimization, transportation, medicine, data classification, and other things. Therefore, it is proposed to develop a discussion that highlights the effectiveness of advanced optimization algorithms in the aforementioned domains and their potential applications for the decision problem investigated in this study.

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Persian Abstract

چکیده

اخیراً تفاوت در مؤثرترین شایستگی ها عامل اصلی رقابتی در سازمان ها تلقی می شود. برای این منظور، سازمان ها به دنبال بهبود تعدادی از قابلیت های عملکردی، تخصص و ظرفیت های خود برای ارتقای حوزه عملیاتی خود هستند. بنابراین، زمانی که یک سازمان بر کیفیت خدمات یا محصولات خود تمرکز می کند، در تلاش است تا قابلیت نگهداری را بهبود بخشد تا مزیت رقابتی به دست آورد. در این مطالعه، یک مدل ریاضی حلقه بسته، چند هدفه، چند سطحی، چند کالایی و چند چرخه برای یک زنجیره تامین با اجزای سازنده و توزیع کننده برای مکان یابی و تخصیص اقلام ارائه شده است. مدل ارائه شده می تواند عوامل محیطی، اقتصادی و اجتماعی را در طول زنجیره کنترل کند. یکی از مهمترین و منحصر به فردترین جنبه های مطالعه حاضر، در نظر گرفتن سناریوهای مختلف در زنجیره تامین حلقه بسته (CLSC) است تا کیفیت محصولات تولیدی و حمل شده با توجه به فسادپذیری مورد توجه قرار گیرد. علاوه بر این، برای کنترل اثرات زیست محیطی، مدل می تواند انتشار کل CO_2 را به حداقل برساند. این مشکل در مقیاس های کوچک، متوسط و بزرگ با استفاده از روش های Epsilon Constraint و NSGA-II حل می شود. با توجه به نتایج به‌دست‌آمده، جریان بر اساس سناریوی رونق بیشتر از سناریوی رکود است. در نهایت، با توجه به تحلیل حساسیت، تعداد مراکز تأسیس شده با افزایش تقاضا افزایش می‌یابد. نتایج نشان می‌دهد که مدل NSGA-II می‌تواند رفتار مدل را به خوبی در بلندمدت پیش‌بینی کند. برای این منظور از دو شاخص MID و SM استفاده شده است که مقدار استاندارد MID برابر با ٦.٥٦ و SM استاندارد برابر با ۰.۱۳۹ است.