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A novel blockchain-based Sustainable Supply Chain model in the Pharmaceutical Industry

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Abstract

The ever-increasing changes in the business world and the new requirements of production and trade in the present era have provided the basis for the emergence of new attitudes. The supply chain in the current environment is complex and diverse. Based on the change in the market environment, the demand for the supply chain has also created a lot of uncertainty. Also, with transformative technologies in the new era, managing supply chain uncertainties has taken on a new face. One of these technologies is blockchain technology. The importance of drug safety, always one of the biggest concerns, cannot be overstated as it directly affects the public health of society. It is a shared responsibility of all stakeholders in the pharmaceutical industry to establish a reliable and traceable pharmaceutical system. For this reason, in this research, an effort has been made to provide a model for sustainable supply chains in a state of uncertainty, emphasizing blockchain technology as a tool to fulfill this responsibility, fostering a sense of collective duty and commitment in the audience.

Keywords: sustainable supply chain, smart supply chain, blockchain-based supply chain, pharmaceutical industry

1- Introduction

A Supply chain is an integrated process in which a group of organizations such as suppliers, manufacturers, distributors, and retailers work together to transform raw materials into final products and distribute them to final customers. The pharmaceutical supply chain (PSC) comprises multiple stakeholders, including raw material suppliers, manufacturers, distributors, regulatory authorities, pharmacies, hospitals, and patients. The pharmaceutical, medical, and health industries have one of the highest standards for product safety, security, and stability, which is vulnerable to the smallest disruptions. However, with the help of digital

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technology, supply chain management in health and pharmaceuticals can be monitored in a safe and transparent manner, significantly reducing delay and human error. This technology empowers us to monitor costs, labor, and even waste emissions anywhere in the supply chain. It can also be used to verify the authenticity of products by tracing them back to their original source, and with the counterfeit drug market causing a loss of $200 billion annually to the original market, the application of technology in health and pharmaceuticals can be a powerful tool in our control (Dehshiri et al., 2024).

Electronic medical records (EMRs) are the backbone of any modern healthcare system. However, because medical records are often so long and get more complicated with each visit to the doctor, it's not always easy for healthcare providers to get them. Drug safety is always one of the biggest concerns because it directly affects the general health of society. Researchers and industrialists widely acknowledge that establishing a reliable and traceable pharmaceutical system is essential to ensure drug safety, from drug production to procurement to sales. For this reason, during the past few decades, pharmaceutical industries and regulatory organizations have tried to solve supply chain security problems by adopting new policies. However, in today's digital world, policy alone cannot solve the challenges of legacy platforms that are not optimized to operate in the shared data economy. Recently, emerging technologies such as blockchain have been proposed in drug supply, which can be used in the security and optimization of the drug supply chain. Blockchain provides a distributed, secure, and transparent approach to exchange information in the supply chain. Blockchain can be used to know the processes in the supply chain and its agents and to determine the exact time and place of each one. The information entered in the blockchain technology platform is immutable, and other chain partners can track the shipment, delivery, and transportation. The features of decentralization, transparency, openness, immutability, data provenance, timestamping, and auditability are useful in ensuring that the problem of counterfeit and distributed drugs is contained. All transactions related to prescription drugs, from their production, distribution, and delivery to the final consumer, are registered, and all stakeholders are related. In this way, any change or action in this area is detected by each party, and with this approach, the production and distribution of counterfeit drugs becomes impossible. The traceability of low-quality drugs reaches the manufacturer, and even stolen drugs can be traced if registered at the time of production (Ghahremani-Nahr et al., 2022).

The use of the Internet, cloud computing, and the Internet of Things has increased the efficiency of businesses. With businesses becoming increasingly competitive and complex, information and communication technology must coordinate activities and services to create a competitive advantage and differentiate from competitors. One of the latest examples of these technologies is blockchain technology. Blockchain technology allows patients to ensure the authenticity of medicines. This system can even be programmed to provide patients with the production date and other drug-related details. Fraud detection in drug transactions can also be another application of blockchain. In blockchain, every transaction is verified due to its legitimacy (Korpela et al., 2017).

The features of decentralization, transparency, openness, immutability, data provenance, time stamp, and auditability are the positive outcomes of digital technology in the pharmaceutical industry. The use of electronic health records and personal health records, access control, interoperability, clarity of data origin, and data integrity are some of the beneficial outcomes of digital technology in this industry. The researcher, considering the positive impact of digital technology on both customers and related organizations, is enthusiastic about providing appropriate guidelines to the practitioners of this industry. This research aims to explore the impact of digital technology in fulfilling the economic and social considerations of the healthcare industry, instilling a sense of optimism about the industry's future. In such a way that those involved can, by creating information platforms, change the different parts of this industry from the traditional form to a new and efficient form. Therefore, the main question of this research is how to provide a sustainable supply chain model in uncertain conditions and based on blockchain in the pharmaceutical industry.

2- Literature Review

The importance of the impact of digital transformation in the world is increasing daily. The digital transformation trends in various industries are concepts, the knowledge of which helps develop digital transformation. Basically, digital development owes to the development of several concepts, including the following. Internet of Things, cloud computing, mobile applications, social media, virtual and augmented reality, data analysis, artificial intelligence, intelligent guidance systems, startups, digital marketing and digital financial channels, and blockchain. These resources can be provided quickly, with minimal effort and minimal interaction with the service provider. These technologies increase investment productivity by eliminating many service costs (Gharachorloo et al., 2021).

Blockchain also supports more advanced concepts, such as smart contracts. A blockchain-based smart contract is a contract between two or more parties that is executed and stored on the blockchain. A smart contract is a programmable contract that can be understood as an automatically executed contract; when the blockchain reaches a predetermined position, the contract is automatically executed. Smart contracts are computer transaction agreements that enforce the terms of the contract. Since the smart contract of entities in a distributed blockchain network can eliminate the need for trusted officials to execute contracts and reduce transaction costs. Based on the principle of decentralization in eliminating intermediaries, smart contracts are essential blockchain applications. It can automatically transfer assets when certain conditions are met (Aliahmadi et al., 2023).

The supply chain is the process of obtaining the product from the manufacturer and delivering it to the end-user or consumer. Any product can have a supply chain, including clothing, cars, and medical equipment. The healthcare supply chain, like other supply chains, includes many participants, starting with the supplier of raw materials and moving towards the manufacturer, wholesaler, and distributor, and finally, the pharmaceutical manufacturer. The digital supply chain is defined as a globally connected data-based mechanism with an integrated, customer-oriented, and intelligent system that applies new technologies to provide valuable products and accessible services. The drug supply chain is complex and orderly. The efficiency of the supply chain influences drug costs. In a competitive environment, the agility and reliability of the supply chain are the most critical elements for the success of an organization, but the current position must be guaranteed (Aliahmadi et al., 2022).

Companies in the pharmaceutical industry are now expected to be responsible for economic, social, and environmental needs. Moreover, environmental protection and sustainability can improve public perceptions of production efficiency (Surucu-Balci et al., 2024). Adopting sustainable operations helps businesses differentiate themselves from the competition by reducing unnecessary risk and waste generation, increasing material and energy efficiency, and innovating through new and environmentally friendly products. This approach helps increase business performance and profitability and strengthens their activities. Blockchain protects medical and health data from hackers and cybercriminals. Medical data management in big data, digital financial channels, and blockchain is an important part of the medicine supply chain (Quayson et al., 2024, Nozari et al., 2012). Some medicinal products, such as vaccines, require temperature and humidity control during transportation. Using the Internet of Things during transmission makes it possible to quickly discover inappropriate environmental conditions and send a warning to the parties on the blockchain platform. Patients can protect the transportation conditions of vaccines throughout the supply chain. In this process, smart contracts play a vital role in checking the validity of products, the provisions of protocols and predetermined rules, and terminating contracts. In addition, many blockchain companies, such as startups, recommend blockchain projects to track pharmaceutical product characteristics such as location, ingredients, temperature positions, and product images. Another is the Ledger Domain, which uses barcode coding and blockchain for patients to track and trace medications. The need for drug security is driving the implementation of blockchain in the drug supply chain (Nozari, 2024 , Aliahmadi et al., 2013, Aliahmadi et al., 2015).

The pharmaceutical industry is overseen by government departments such as the Food Administration and other non-governmental organizations such as the World Health Organization. Organizations are required to follow the laws and fight against fake products. Developed countries apply more practical actions to detect fake medicine than developing countries. Much research has recently been conducted on technology-based supply chains in the medical industry. Agrawal et al. (2022) investigated the blockchain network in drug manufacturing, which allows manufacturers to effectively control a drug in the supply chain while improving security and transparency in the entire process. In this research, the cost and time of the manufacturing company to transfer the drug to the end user will be minimized by providing mathematical models of direct and reverse supply chains. The direct supply chain model supports drug delivery from manufacturer to end user in less time with a reliable mode of delivery. The reverse supply chain model explicitly focuses on reducing the additional time and cost imposed on the manufacturer in pursuing defective drug readouts. In addition, a real implementation of a blockchain-enabled supply chain management system is performed to demonstrate process transparency.

Hald & Kinra (2020) investigated the role and limitations of blockchain technology (BCT) in managerial work practices and the conceptualization of the relationship between technology and performance in supply chain management (SCM). In this review, a series of propositions have been developed that show how the use of BCT in supply chains can be understood to enable and limit supply chain management and performance simultaneously. This analysis identifies four enabler identities and three blockchain identities to explain how this technology "facilitates" or "hinders" SCM and supply chain performance. Traceability, which derives from its ability to create specificity and immutability of data, was identified as a key technological innovation. Wang et al. (2019) investigated how blockchain technology affects supply chain practices and policies. They introduced the value of such technologies for supply chain management in four areas. Expanded visibility and traceability, digitalization of the supply chain, improved data security, and smart contracts.

Using resource-based perspectives, Nilsson & Linn (2019) outlined the supply chain and blockchain concepts. In this study, the identification of the types of resources required for the successful implementation of blockchain and, ultimately, the potential achievement of a beneficial supply chain perspective has been targeted. The results of their investigations showed that if the participants in the supply chain have adequate resources to dedicate to this technology, the supply chain may be improved. This research identified the positive effects of blockchain, including access, transparency, trust, and information technology security.

3- Mathematical Modeling

This part presents a multi-objective mixed integer mathematical programming model, which seeks to optimize the drug supply chain based on blockchain technology. This three-level chain includes producer, distributor, and pharmacy. First, the model is described, and then the indices, parameters, decision variables of the objective functions and limitations are described.

The use of blockchain in supply chains, like other fields, is becoming increasingly significant. Blockchain acts as a ledger that can record information such as inventory and information related to financial affairs, which leads to the awareness of all nodes and all supply chain layers about inventory and demand. This issue is very important for many supply chains, including pharmaceutical supply chains, because medicine is considered a rapidly consumed commodity and, in some cases, perishable; on the other hand, knowing the amount of stock and the amount of its demand is considered a necessity. to be Therefore, the use of blockchain systems in drug supply chains is very important. However, because connecting to the blockchain system can have costs for the relevant nodes, it should be noted that some nodes may not choose to connect to the blockchain, which can affect the determination of inventory and demand. They are effective.

Another important point is that discussing sustainability, i.e., the three economic, environmental, and social goals, can also be important in drug supply chains. In this way, despite the importance of timely delivery of medicine or cost reduction, social issues such as employment generation and environmental issues, such as energy consumption, especially in supply chains where there is a possibility of spoilage of goods, and therefore, nodes from the refrigerator for storage use is considered important. In fact, the current research seeks to provide a sustainable supply chain model based on blockchain in such a way that it includes manufacturers, distributors, and pharmacies. Distributors and pharmacies have the possibility to connect to the blockchain system. If they connect to these systems, they will automatically record their drug needs. For example, pharmacies record how much medicine they have sold and what kind of medicine they need in the given period. This is also true for distributors. Distributors also make informed decisions for future orders through the blockchain system, which registers drugs and their amounts. However, pharmacies or distributors not connecting to this system face uncertain or scenario demand. That is, it is not clear how much their demand is in each period. Therefore, connecting to the blockchain system leads to the certainty of the demand because the demand is recorded by the blockchain, while not connecting to it leads to the uncertainty of the demand. Finally, a three-objective model is designed based on reducing costs, reducing environmental issues, and increasing employment or social responsibility.

The assumptions of the model are as follows:

1- The model is uncertain
2- It is possible to choose and not choose the blockchain system.
3- The supply chain has three levels.
4- It is a multi-product model.
5- It is a multi-period model.
6- The model is based on three objectives of sustainability.
7- The amount of employment is determined based on the inventory and the amount of production
8- The amount of energy consumption is determined based on the inventory and the amount of production.
9- The cost of maintenance is different for each pharmacy and distributor.
10- The cost of production is considered different for each producer.
11- Producers, distributors, and pharmacies have limited capacity.

Indices

i	Producer
j	Distributor
k	pharmacy
p	the product
t	period
s	scenario

The parameters

FJ_j	The cost of building a distributor j
FK_k	The cost of building a pharmacy k
DIJ_{ij}	Distance between producer i and distributor j
DJK_{jk}	Distance between distributor j and pharmacy k
TC	Unit transfer fee

BDK_{kt}	The amount of demand for product p in pharmacy k in period t recorded by the blockchain system
BDJ_{jt}	The amount of demand for product p at distribution center j in period t recorded by the blockchain system
DK_{kts}	The amount of demand for product p in pharmacy k in period t without blockchain system under scenario s
DJ_{jts}	Demand rate of product p at distribution center j in period t recorded without blockchain system under scenario s
$CAPI_i$	Producer capacity i
$CAPJ_j$	distributor capacity j
$CAPK_k$	Pharmacy capacity k
BCK	The cost of connecting to the blockchain system for the pharmacy
BCJ	The cost of connecting to the blockchain system for the distributor
MC_i	Unit cost of drug production by the manufacturer i
DC_j	The unit cost of drug storage by the distributor j
KC_k	Drug storage unit cost by pharmacy k
ECI_{ip}	The amount of energy consumed per unit of product p by producer i
ECJ_{jp}	The amount of energy consumption per unit of product p by distributor j
ECK_{kp}	The amount of energy consumption per unit of product p by pharmacy k
$EMPI$	The number of labors required for the producers of each unit of product
$EMPJ$	Number of labors required for distributors per unit of product
$EMPK$	The number of labors required for the pharmacy per unit of inventory
MM	A large number

Decision variables

XJ_j	1 if distributor j is built and zero otherwise
XK_k	1 if pharmacy k is built and zero otherwise
XIJ_{ij}	Transfer flow of product p between manufacturer i and distributor j
XJK_{jk}	Transfer flow of product p between distributor j and pharmacy k
YBK_{ktp}	Inventory of product p in pharmacy k in period t based on blockchain system
YBJ_{jtp}	Inventory of product p in distribution center j in period t based on blockchain system
YK_{ktsp}	Inventory of product p in pharmacy k in period t without blockchain system under scenario s
YJ_{jtsp}	Inventory of product p at distribution center j in period t without blockchain system under scenario s
ZK_k	1 if pharmacy k connects to the blockchain system and zero otherwise
ZJ_j	1 if distributor j connects to the blockchain system and zero otherwise
U_i	The amount of drug production by the manufacturer i
$JOBI_{ip}$	The amount of production of employment by the producer i
$JOBJ_{jp}$	The amount of employment produced by the distributor j
$JOBK_{kp}$	The amount of employment generated by the pharmacy k
VI_{ipt}	The energy consumption of producer i in period t for product p

VJ_{jpt} The energy consumption of distributor j in period t for product p

VK_{kpt} Energy consumption of pharmacy k in period t for product p

Objective functions

$$\min z1 = \sum_j FJ_j\, XJ_j + \sum_k FK_k\, XK_k + \sum_i \sum_j DIJ_{ij}\, TC\ \ XIJ_{ij} + \sum_j \sum_k DJK_{jk}\, TC\, XJK_{jk} + \sum_j BCJ\ \ Z_j + \sum_j BCK\ \ Z_k + \sum_i MC_i\ \ U_i + \sum_j \sum_t \sum_p DC_j\ \ YBJ_{jtp} + \sum_k \sum_t \sum_p KC_k\ \ YBK_{ktp} + \sum_j \sum_t \sum_p \sum_s DC_j\ \ YJ_{jtsp} + \sum_k \sum_t \sum_p \sum_s KC_k\ \ YK_{ktsp} \quad (1)$$

$$\min z2 = \sum_i \sum_p \sum_t VI_{ipt} + \sum_j \sum_p \sum_t VJ_{jpt} + \sum_k \sum_p \sum_t VK_{kpt} \quad (2)$$

$$max\ z2 = \sum_i \sum_p JOBI_{ip} + \sum_j \sum_p JOBJ_{jp} + \sum_k \sum_p JOBK_{kp} \quad (3)$$

S.t

$$\sum_j XJ_j \geq 1 \quad (4)$$

$$\sum_k XK_k \geq 1 \quad (5)$$

$$\sum_i XIJ_{ij} \leq\ \ CAPJ_j \quad (6)$$

$$XIJ_{ij} \leq MMXJ_j \quad (7)$$

$$\sum_j XJK_{jk} \leq \sum_i\ \ XIJ_{ij} \quad (8)$$

$$\sum_j XJK_{jk} \leq\ \ CAPK_k \quad (9)$$

$$XJK_{jk} \leq MMXK_k \quad (10)$$

$$U_i \leq \sum_j XIJ_{ij} \quad (11)$$

$$U_i \leq CAPI_i \quad (12)$$

$$YBJ_{jtp} \leq MMZ_j \quad (13)$$

$$YBJ_{jtp} = YBJ_{jt-1\,p} + \sum_i\ \ XIJ_{ij} - BDJ_{jt} \quad (14)$$

$$YBK_{ktp} \leq MMZ_k \quad (15)$$

$$YBK_{ktp} = YBK_{kt-1\,p} + \sum_j\ \ XJK_{jk} - BDK_{kt} \quad (16)$$

$$YJ_{jtsp} = YJ_{jt-1\,p} + \sum_i\ \ XIJ_{ij} - DJ_{sjt} \quad (17)$$

$$YK_{ktsp} = YK_{kt-1\,sp} + \sum_{j} XJK_{jk} - DK_{kts} \quad (18)$$

$$VI_{ipt} = ECI_{ip}U_i \quad (19)$$

$$VJ_{ipt} = ECJ_{jp}YBJ_{jtp} + ECJ_{jp}YJ_{jtsp} \quad (20)$$

$$VK_{kpt} = ECK_{kp}YBK_{ktp} + ECK_{kp}YK_{ktsp} \quad (21)$$

$$JOBI_{ip} = EMPI/U_i \quad (22)$$

$$JOBJ_{jp} = \frac{EMPJ}{YBJ_{jtp} + YJ_{jtsp}} \quad (23)$$

$$JOBK_{kp} = \frac{EMPK}{YBK_{ktp} + YK_{ktsp}} \quad (24)$$

$$XJ_j \in \{0.1\} \quad (25)$$

$$XK_k \in \{0.1\} \quad (26)$$

$$ZK_k \in \{0.1\} \quad (27)$$

$$ZJ_j \in \{0.1\} \quad (28)$$

$$XIJ_{ij} \geq 0 \quad (29)$$

$$XJK_{jk} \geq 0 \quad (30)$$

$$YBK_{ktp} \geq 0 \quad (31)$$

$$YBJ_{jtp} \geq 0 \quad (32)$$

$$U_i \geq 0 \quad (33)$$

$$JOBI_{ip} \geq 0 \quad (34)$$

$$JOBJ_{jp} \geq 0 \quad (35)$$

$$JOBK_{kp} \geq 0 \quad (36)$$

$$VI_{ipt} \geq 0 \quad (37)$$

$$VJ_{jpt} \geq 0 \quad (38)$$

$$VK_{kpt} \geq 0 \quad (39)$$

Equation (1) seeks to minimize the costs of the drug supply chain. Equation (2) seeks to minimize the environmental issues of the drug supply chain. Equation (3) seeks to maximize social responsibility in the drug supply chain. Equation (4) shows that at least one distributor should be built. Relation (5) shows that at least one pharmacy should be built. Relation (6) shows that the total transfer flow to the distributors cannot exceed their capacity. Equation (7) states that if the distributor is not built, there will be no flow for it. Equation (8) shows that the total flow sent from distributors to pharmacies cannot naturally exceed the total flow sent from manufacturers to distributors should be more. Equation (9) shows that the total flow sent from all distributors to pharmacies cannot exceed the capacity of pharmacies. Relationship (10) states that if a pharmacy is built, there will be a flow for it. Equation (11) shows that the amount of production by a producer cannot be more than the flow sent to all distributors. Equation (12) shows the limitation of the producer's capacity. chain is selected for a distributor; the inventory is recorded based on it. Equation (14) seeks to calculate the amount of inventory based on the blockchain. Equation (15) states that if the blockchain system is selected for the pharmacy, the inventory is based on the blockchain chain is calculated. Equation (16) calculates the amount of inventory for the pharmacy based on blockchain. Equation (17) calculates the amount of inventory without blockchain for distributors. Equation (18) calculates the amount of inventory without blockchain for Pharmacies. Equation (19) calculates the amount of energy consumption for the manufacturer. Equation (20) deals with the calculation of the amount of energy consumption for the distributor. Equation (21) deals with the calculation of the amount of energy consumption for the pharmacy. Equation (22) deals with the calculation of the amount of employment produced by the manufacturer. Equation (23) deals with the calculation of the amount of employment produced by the distributor. Equation (24) deals with the calculation of the amount of employment produced by the pharmacy. Equation (25) to (28) determine the range of binary variables. Relations (29) to (41) include the range of integer variables.

4- Solution method

The $NSGA\ II$ algorithm is one of the fastest optimization algorithms, which has less operational complexity than other methods and obtains Pareto optimal points by using the principle of non-overcoming and calculating the crowding distance. In NSGA II, the preservation of elitism and fragmentation is considered simultaneously. The selection of the new population in each step of this method is based on the principle of predominance, and by using elitism and ranking of the population in each step of the solution, it selects the best non-defeated answers and goes to the next step.

Also, to observe the appropriate distribution of the density of answers in this algorithm, a concept called crowding distance is used. In general, to sort a population of size n based on the levels of outliers, each answer is compared to all other answers in the population to determine whether that answer is an outlier or not. In the end, there are several solutions, none of which are dominant or defeated by each other, so these solutions form the first boundary of non-defeated boundaries. These answers are transferred to the set F_1. To determine the answers in the next boundaries, the answers in the first boundary are temporarily ignored and the above process is repeated, and this time the answers are transferred to the F_2 set and get the second rank. This process continues for all non-defeated answers of the population. One of the desired criteria of the evolutionary algorithm on the way to reach the optimal Pareto boundary is to maintain the variety and extent of the answers in the set of obtained answers. Sorting the non-defeated ones is a procedure to reach better answers, and the diversity mechanism also tries to maintain diversity and breadth in these answers. In this algorithm, this is done by the crowding distance in this way. A smaller value of the crowding distance of an answer indicates a greater density of answers around it.

For the next step, the solutions that are in an area with less density or in other words with a greater crowding distance should be selected. By doing this, the diversity and dispersion in the obtained answers increases. The purpose of using the crowding distance in NSGA II is to create diversity in the answers of the population and it indicates the density of the answers next to a specific answer. The crowding distance for answers sorted in ascending order and specific to set F is obtained from equation (40).

$$CD(X^1) = CD(X^S) = \infty$$

$$CD(X^i) = \left[\frac{Z_1(X^{i+1}) - Z_1(X^{i-1})}{Z_1(X^S) - Z_1(X^1)}\right] + \left[\frac{Z_2(X^{i+1}) - Z_2(X^{i-1})}{Z_2(X^S) - Z_2(X^1)}\right], i = 2, \dots, S-1 \qquad (40)$$

In the above relation, $CD(X^i)$ is the crowding distance for the solution X^i. After merging the parent and offspring populations, non-regressive sorting is performed and steps 7 and 8 described below are performed. Based on step 10, the crowding distance criterion is used to create a subset of the last non-defeated set and due to the increase in the size of the next population:

Step 1: Create an initial population $P_0$of size N with random answers and set $t = 0$,

Step 2: If the stop condition is not established, return to P_t.

Step 3: Select N parents from the population P_t using the binary competitive selection operator,

Step 4: By applying the crossover and mutation operators on the population P_t, create a population of children Q_t of size N,

Step 5: Put $R_t = P_t \cup Q_t$,

Step 6: Use the non-inferior ranking method to determine the Pareto sets F_i in the population R_t.

Step 7: Put $P_{t+1} = \emptyset$ و $i = 1$،

Step 8: until $|P_{t+1}| + |F_i| < N$

a. Add the answers of the set $F_i$to the population P_{t+1}, and

b. Put $i = i + 1$.

Step 9: Sort the answers of the set F_i according to the crowding distance and in descending order.

Step 10: As much as $N - |P_{t+1}|$ Transfer from the first solutions F_i to the population P_{t+1}, and

Step 11: Set $t = t + 1$ and return to step 2.

5- Research findings

In order to analyze the model in this research, 20 modes have been considered. By increasing the dimensions of the model problem, it can be solved to some extent, and from the tenth example onwards, the problem cannot be solved using the exact method, so meta-heuristic algorithms should be used to solve the problem. The selected algorithm at this stage is the NSGA II algorithm, in this section we are looking to compare its results with the exact method. This comparison is made in Table 1.

Table 1: Comparison of exact method and NSGA II algorithm

Problem	The exact method				NSGA II algorithm				Gap			
	Cost	environmental issues	Social responsibility	Calculation time	Cost	environmental issues	Social responsibility	Calculation time	Cost	environmental issues	Social responsibility	Calculation time
1	570845	42322	17096	5	570841	42320	17089	5	4	2	7	0
2	572065	43736	17260	15	572058	43732	17245	15	7	4	15	0
3	573405	44939	17429	20	573374	44930	17412	18	31	9	17	2
4	574844	46174	17603	28	574810	46154	17585	24	34	20	18	4
5	576709	48045	17721	33	576670	48020	17703	29	39	25	18	4
6	577916	49171	17896	41	577875	49138	17875	37	41	33	21	4
7	579826	50580	18072	46	579780	50546	18051	42	46	34	21	4
8	581712	51674	18208	51	581656	51635	18173	47	56	39	35	4
9	583109	53393	18335	61	583037	53348	18292	56	72	45	43	5
10	584214	54513	18474	71	584131	54468	18424	66	83	45	50	5
11	…….	…….	…….	low memory	599006	55832	19716	72				
12	…….	…….	…….	low memory	618747	56979	21410	77				
13	…….	…….	…….	low memory	637535	58661	23371	82				
14	…….	…….	…….	low memory	654954	60030	24816	92				
15	…….	…….	…….	low memory	673999	61372	25817	102				
16	…….	…….	…….	low memory	687268	63138	27162	108				
17	…….	…….	…….	low memory	706465	64324	28807	116				
18	…….	…….	…….	low memory	722972	65832	30002	126				
19	…….	…….	…….	low memory	737574	66908	31373	132				
20	…….	…….	…….	low memory	748592	68643	32646	142				

As it can be seen, with the increase in the dimensions of the problem, the gap between the two methods increases and the biggest gap is observed in the cost. which indicates the superiority of this method over the exact method. On the other hand, with the increase in dimensions, the distance between the results of the two methods increases, and the calculation time also has a huge gap, which of course is the biggest gap in cost, then in environmental issues, and finally in social issues.

In the following, the sensitivity analysis is discussed. In the sensitivity analysis, the reaction of the model to changes in some parameters is checked, considering that the focus of the present research is on the use of the blockchain system, in this section, the effect of connecting to the blockchain system and costs are examined. imposed is addressed. In the table below, it is checked that the connection to the blockchain system will cause changes in the objective functions of the current research, which is based on sustainability. The results are presented in Table 2.

Table 2: Sensitivity analysis of connecting and not connecting to the blockchain system in the drug supply chain

Problem	Connecting to the blockchain system			No connection to the blockchain system			Contradiction			Percent discrepancy		
	Cost	environmental issues	Social responsibility	Cost	environmental issues	Social responsibility	Cost	environmental issues	Social responsibility	Cost	environmental issues	Social responsibility
1	570841	42320	17089	583171	43255	16230	12330	935	859	0.021143	0.021616	0.052927
2	572058	43732	17245	589325	44661	16490	17267	929	755	0.0293	0.020801	0.045785
3	573374	44930	17412	583573	45613	16613	10199	683	799	0.017477	0.014974	0.048095
4	574810	46154	17585	585873	46901	16750	11063	747	835	0.018883	0.015927	0.049851
5	576670	48020	17703	588174	48550	16821	11504	530	882	0.019559	0.010917	0.052434
6	577875	49138	17875	593522	49669	17064	15647	531	811	0.026363	0.010691	0.047527
7	579780	50546	18051	591843	51370	17180	12063	824	871	0.020382	0.01604	0.050698
8	581656	51635	18173	594885	52508	17617	13229	873	556	0.022238	0.016626	0.03156
9	583037	53348	18292	602175	54111	17308	19138	763	984	0.031781	0.014101	0.056852
10	584131	54468	18424	595455	55396	17862	11324	928	562	0.019017	0.016752	0.031463
11	599006	55832	19716	616141	56614	19126	17135	782	590	0.02781	0.013813	0.030848
12	618747	56979	21410	638603	57925	20559	19856	946	851	0.031093	0.016331	0.041393
13	637535	58661	23371	649376	59584	22754	11841	923	617	0.018234	0.015491	0.027116
14	654954	60030	24816	673627	60915	24310	18673	885	506	0.02772	0.014528	0.020814
15	673999	61372	25817	690086	62335	24825	16087	963	992	0.023312	0.015449	0.03996
16	687268	63138	27162	702293	63760	26236	15025	622	926	0.021394	0.009755	0.035295
17	706465	64324	28807	724996	64951	28124	18531	627	683	0.02556	0.009653	0.024285
18	722972	65832	30002	733061	66402	29433	10089	570	569	0.013763	0.008584	0.019332
19	737574	66908	31373	749434	67548	30757	11860	640	616	0.015825	0.009475	0.020028
20	748592	68643	32646	766986	69304	31898	18394	661	748	0.023982	0.009538	0.02345

There is a difference between connecting and not connecting to the blockchain system, and connecting to the blockchain system can reduce costs and environmental issues and improve social issues, i.e. employment. This means that connecting to the blockchain system is generally beneficial to the supply chain system. It is medicine, but the noteworthy point is that with the increase in the dimensions of the gap between the two modes, it gradually decreases, that is, the benefits from cost reduction and environmental issues and the benefits from increasing employment in the state of connection to the blockchain system decrease with the increase in dimensions. And the larger the dimensions, the less these benefits, which is an important point. Therefore, in high dimensions, the benefits of connection generally decrease.

6- Conclusion

The point of the current investigation was to supply a maintainable supply chain shown beneath vulnerability and based on blockchain. Based on this, the library thinks about what was conducted, the comes about of which indicates an investigative crevice within the field of utilizing blockchain within the maintainable sedate supply chain. Based on the studies, a three-objective feasible supply chain show was outlined based on maintainability. The primary objective is cost diminishment, the moment objective is to diminish natural issues, and the third objective is to extend business or social issues. The displayed demonstration was, to begin with, illuminated in little measurements to check its legitimacy; at that point, it was analyzed in expansive measurements utilizing NSGAII calculation. It appears that the utilization of the blockchain framework can take a toll on enhancement and natural issues. and increment work, and in common at all levels, it can lead to enhancement of answers, whereas not utilizing it can increment costs and, of course, instability since not utilizing blockchain will diminish the request in conveyance centers and drug stores. The result is dubious and the increment of this instability leads to the disintegration of the answers.

In this study, the medicate supply chain model was separated into three parts, creating conveyance centers and drug stores, which shaped the layers of the supply chain. In this chain, the hubs had the specialist to connect the blockchain framework, that is, any drug store or conveyance center seems to connect the framework. Blockchain is associated, which brings benefits and costs to the supply chain. At long last, three maintainability objectives, i.e., diminishing costs, lessening natural issues, and increasing social duty within the business frame, were taken within the current inquiry about the show. The joining of drug stores and dispersion centers to the blockchain framework despite the burden of an expense can cause the demand to be decided, and the request to be enrolled within the blockchain framework, whereas not interfacing them to the blockchain framework can cause the instability of the request.

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