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# Designing an Incorporated Multi-Objective Green Supply Chain- Work Cost Model under non- Definitive Conditions

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**CHRONICLE**

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**Abstract**

As the subject of environment was connected to the economy and countries concluded that environmental protection can increase productivity, different attitudes have been taken to obtain these ideals, which one of them is the green supply approach. Greening the supply chain needs new inputs that create chances for companies to invest in the design and production of greener products and meet sustainability requirements, and this includes not only consumer products, but also contains the inputs from suppliers which involve them in creating green markets. Despite the scope of green supply chain management, designing a green network is necessary. So, in this research, environmental considerations have been integrated with economic considerations, in which non-definitive conditions have been considered.



## ۱. Introduction

The globalization of the economy and the development of information technology have led to the supply-oriented market to change to the demand-driven market and organizations to understand the necessity of meeting customer requirements to meet their survival (Rad et al., ۲۰۱۸). Nowadays, green supply chain managers in leading companies try to use green logistics and improve their environmental performance throughout the supply chain as a strategic weapon to achieve a competitive advantage of profit sustainability by creating utility and environmental satisfaction throughout the supply chain. Nowadays, many countries in the world pay a lot of attention on protecting environment and exerting

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environmental rules. So, industry owners and producers in supply chain design and development, consider environmental factors more than past (Nourjanni et al., ٢٠١٧). Environmental performance of an organization is influenced by the environmental performance of its suppliers. Selecting a green supplier is also a strategic decision to be more competitive in today's global marketplace. This becomes even more important when companies are searching for new markets and consequently new suppliers (Kadzinski et al., ٢٠١٧). The point of supply chain and its management is one of the most important and non-separable points in human life. Considering it, especially in manufacturing companies, factories, organizations, and...., can significantly help decreasing costs, making more profit, attract customer's satisfaction, planning, staying in the market and obtaining a competitive advantage over other competitors and the organization in general, will improve. After the appearance of the supply chain, environmental points because of its importance and having a healthier environment, were considered in this regard and the green supply chain emerged. With this issue, purposes like this became more important and, in many cases, will decrease costs, which is one of the most important and priority purposes in all organizations. Another important feature of the supply chain is the term uncertainty, which brings the model closer to reality. Due to the instability of economic conditions, uncertainty in this issue has been considered differently from previous articles. Since unstable economic conditions affect the demand as well as the prices of raw materials, fuel…, consequently, the demand parameters and the total cost of production and transportation are not definitive. Therefore, in this study, an integrated multi-objective model of green supply chain cost under conditions of uncertainty will be designed. In this research, MATLAB and Gomez software are used by using meta-heuristic algorithms.

## ٢- Theoretical Foundations

### ٢-١- Green Supply Chain

The selection of suppliers in the green supply chain can be considered as the management of suppliers, their products and the environment, which includes environmental protection in the management of suppliers (Yeh and Chang, ٢٠١١). In addition to goals such as meeting legal requirements and protecting the environment, supplying materials and carrying out activities in accordance with or environmental requirements, it can reduce waste costs, energy costs, profitability from recycling materials and parts modernization, compensating for the shortage of some raw materials. It also leads to recycling, improving the image of the organization and attracting customers (Handfield et al., ٢٠٠٢).

### ٢-٢- Supply Chain Management

Supply chain management is a set of approaches used to integrate suppliers, producers, warehouses, and stores effectively to produce and distribute goods in the right amount with the purpose of achieving the required level of service. Total system costs should also be reduced (Ghorbanpour et al., ٢٠١٥). Management in the supply chain can play an effective role in reducing costs and preventing the waste of financial, human and time resources and lead to reforming the structure of energy consumption. The main components of supply chain management are (Talebi and Iron, ٢٠١٤): logistics management in the supply chain, information management and information systems in the supply chain, management of relations between members of the supply chain.

### ٢-٣- The Concept of Green Supply Chain Management

Green supply chain management tries to change the traditional linear chain model from supplier to user and seeks to integrate recycling economics into supply chain management. By doing this, we can have a closed loop with a cyclic chain mode. If the company uses green supply chain management, in addition to solving environmental problems, it will also obtain a relative achievement in competitive advantage. In addition, implementing green supply chain management can prevent green obstacles to have international trade (Huo et al., ۲۰۱۰).

### ۲-٤- Supply Chain Integration and its Purposes

The supply chain includes all activities related to the flow of goods and services, from the raw material stage of the final product to be consumed by the customer. In addition to the flow of materials, these transfers also consist of the flow of information and financial issues (Shafiee, ۲۰۱۳). The integrity effect of supply chain on the supply chain management operation: A company could share its special operational resources and technology knowledge in the organization and with other organizations via the systematic integrity of the supply chain and therefore, improve supply chain management operation (Narasimhan, ۱۹۹۷). The integrated supply chain could be defined as an interactive process in companies in a supply chain to achieve goals which are acceptable for all the other organizations in the chain (Nobely, ۱۹۹۷). Some aspects of the supply chain integrity have direct and positive effects on some particular aspects of performance (Klein et al., ۲۰۱۰).

The purpose of an integrated supply chain is to achieve effective and efficient flows of products and services, information, money and decisions to provide maximum value to the customer at low cost and high speed (Flynn, ۲۰۰٤).

### ۲-٥- Benefits of Green Supply Chain

The advantages of green supply chain management are classified into different groups depending on the different roles of the supply chain, including the environment and society: tangible, intangible and emotional. The material advantageous of green supply chain management contribute to lower environmental burden, lower costs for suppliers, lower costs for the producer, lower cost of ownership for the customer, and lower resource consumption for the community (Yeh et al., ۲۰۱۱). From an intangible point of view, green supply chain management helps to overcome bias and pessimism about the environment, less rejection of suppliers, easier construction for the manufacturer, easier and more amusing for the customer, and better adaptation to society. In terms of emotional benefits, green supply chain management helps to increase the motivation of stakeholders for the environment, a better image for suppliers and producers, a better feeling and quality of life for customers, and the creation of industry in the right direction of society.

### ۲-٦- Uncertainty and Risk in the Supply Chain

Uncertainty and risk in the supply chain have a significant influence on its form, design and operation, which is considered at both tactical and long-term levels.

The environmental uncertainties related to the uncertainty in demand and presentation are a result of the performance of the customers and suppliers. The systematic uncertainties include the existing uncertainties in the production, distribution, gathering and recycling processes (Ozgan et al, ۲۰۰۸). The second kind of uncertainties are a result of unpredicted events such as earthquake, flood, economical crisis and terrorist attacks. These events will lead to customers' dissatisfaction. Since they disrupt the performance of the supply chain members and product delivery will definitely by delayed. Supply chain risk assessment can protect the business and brand interests of the organization against the fundamental and important concept of supply chain failure.

### ۲-۷- Review of Researches

Talebi and Iron (۲۰۱۵) studied the chain supply and choosing supplier risks using the network analysis process. In this study, in line with the risk management of the supply chain, the risks of the Iranian car producing supply chain are identified, then the identified risks are considered as the criteria for choosing the suppliers and the suppliers of Zamyad car company have been categorized using the network analysis method. Ramezani in his research in ٢٠١٧ designed a green closed chain supply chain network in an uncertainty conditions of uncertainty.In this study, we design a multi-level supply chain network with the return of products under uncertainty conditions. The model optimizes economic problems in the first purpose function and optimizes environmental problems in the second purpose function. Finally, the sample examples and their study show the necessity of environmental points and its balance with economic issues in supply chain network design. Yin et al. (٢٠١٧) have used a new dynamic multi variable decision maker to choose the green suppliers in construction projects. In this paper, we suggest a new dynamic multi variable decision-making method in construction projects under time series to confront these problems. This method uses the valued geometrical phase revision method using the operator tool (IVIFGWHM) and the nonlinear multi variable model to calculate the results of the general assessment of the green suppliers. Finally, a green building case study is presented to analyze the practical efficiency of the suggested method. Sarpong et al. (٢٠١٦) have done a research titles assessing the actions of the green supply chain management in the mine industry in fuzzy environment. The green supply chain management action in this study are green information technology and systems, working with suppliers, logistic and operational integrity, internal environmental management, choosing new environment-based innovation methods. The research results indicated that green information technology and systems and managing internal environment have more importance

## ٣- Research Methodology

Based on the objectives of this study, it is applied in terms of purpose. Also, the method used to obtain the main purpose is the simulation method. To achieve the objectives of this research, Gomez and MATLAB software are used. To solve the model in case of uncertainty, the robot model of Gomez software will be used. Then, due to problem being NP Hard, we will solve this model in MATLAB software using meta-heuristic algorithms. The algorithm in question is the TS (Tabu search) algorithm.

The data collection method is library and field method. In this research, in order to calculate and estimate parameters such as mean, percentage, absolute frequency, relative frequency and the like, common descriptive statistics methods are used. GAMS and MATLAB software will also be used to model and analyze the data.

## ٤- Information Analysis

### ٤-١- Modeling

In small dimensions we have considered the number of demands between ١ to ٣٠, in medium dimensions between ٣٠ to ٨٠ and in large dimensions between ٢٥٠ to ١٠٠٠. In the concepts of model implementation in MATLAB software is specified, we must first provide the data under study, which is actually the production of data to get the results according to them. So, we represent Table ١ as the table of problem input information (data production).

Table ١: Problem input information

| Amount | Definition | parameter |
|---|---|---|
| ٣٠ | Number of items | $N$ |
| ١٠٠٠ | Buyer's demand | $D_j$ |
| ٤٢٠ | Sellers's fixed order cost (million dollars) | $A_{jS}$ |

| | | |
|---|---|---|
| ٨٥ | Buyer's fixed order cost (million dollars) | $A_{jB}$ |
| ٨ | Pallet capacity | $K_j$ |
| ٢ | Occupied space | $f_j$ |
| ٢٥٠ | Lower limitation of the order amount | $L_j$ |
| ٦٠٠ | Upper limitation of the order amount | $U_j$ |
| ٤٠٠ | Upper limitation the number of pallets for each order | $M_j$ |
| ١٠ | Number of buyers | $N_e$ |
| ٤ | Number of sellers | $N_n$ |
| ٣ | missed sales | $N_s$ |
| ١٠ to ٢٠٪ | Discount | $Cp_e$ |

### ٤-٢- Simulation results

Figure ١ is the result of the conducting the Harmony search algorithm and Figure ٢ is the result of the Tabu search algorithm (TS).

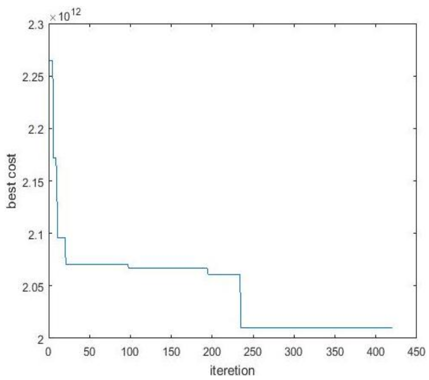

Figure ٢: Result of the Tabu search algorithm

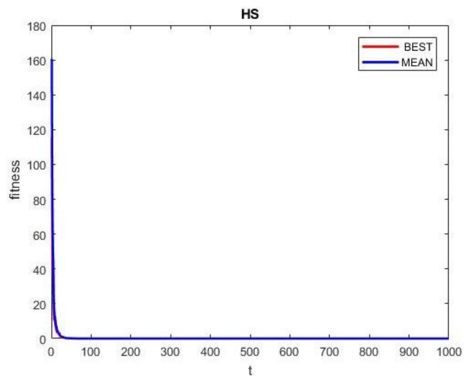

Figure ١: Convergence result of Harmony search algorithm

In Table ٢, we examine ١٠ models with small dimension by using both Harmony search and Tabu search algorithms.

Table ٢: Total cost results in small dimensions (Tabu search algorithm and harmonization)

| distribution $CO_2$ (ppm) | | Total price of chain(dollar) | | Number of order | number of production | sample |
|---|---|---|---|---|---|---|
| **harmony** | **forbidden** | **harmony** | **Forbidden** | | | |
| ٣٦٢ | ٣٥٠ | ١٠٨٦٢٣ | ١٠٠٢٥٤ | ١ | ٢ | ١ |
| ٣٩٧ | ٣٨٤ | ١٤٢٣٨٧ | ١٣٥٦٦٢ | ٥ | ٢ | ٢ |
| ٤٢١ | ٣٩٩ | ١٥٩٩٠٢ | ١٤٦٨٨٢ | ٧ | ٢ | ٣ |
| ٤٦٩ | ٤٥٠ | ١٩٠٠٢١ | ١٧٩٣٠٢ | ١٠ | ٣ | ٤ |
| ٤٧٩ | ٤٥٩ | ٢٥٥٥٧٠ | ١٨١٣٣٢ | ١٢ | ٣ | ٥ |
| ٧٠٤ | ٦٣٢ | ٢٧٦٣٥٢ | ٢٣١٠٢١ | ١٧ | ٤ | ٦ |
| ٩١٠ | ٨٨٥ | ٢٩٦٦٥٣ | ٢٤٩٧٠٤ | ٢٠ | ٤ | ٧ |
| ٩٣٦ | ٩٣٥ | ٣١٠٢٢٤ | ٢٦٥٩٩٥ | ٢٣ | ٤ | ٨ |
| ١٠٧٤ | ١٠٠٢ | ٣٣٧٤٧٠ | ٢٩٧٣٠٢ | ٢٧ | ٥ | ٩ |
| ١١٠٢ | ١٠٢٧ | ٣٥٨٧٢١ | ٣٠٢٦٦٥ | ٣٠ | ٥ | ١٠ |

A comparative graph of the cost of both algorithms for the small dimension model is shown in Figure ٣. Figure ٤ also represents a comparison between carbon dioxide distributions between the two algorithms.

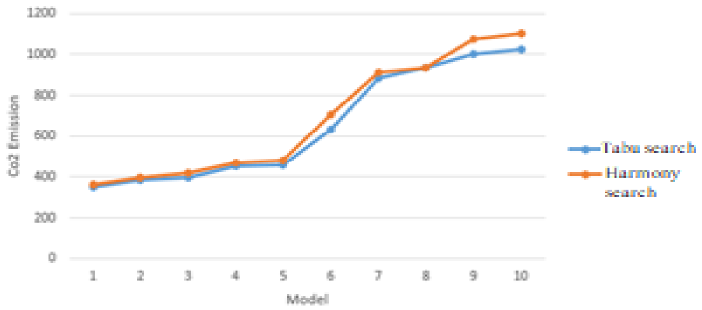


Figure ٤: Comparison of carbon dioxide emissions using two algorithms

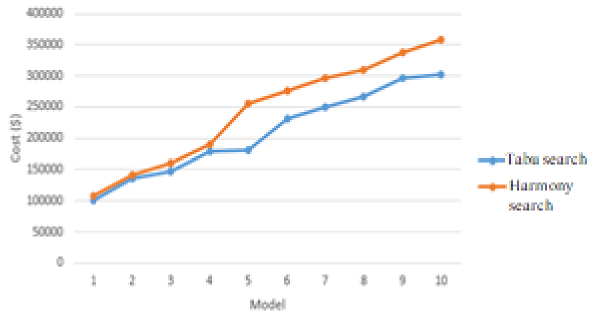


Figure ٣: Comparison of total chain cost using two algorithms

As it is noticed in figure ٣, the Harmony Search algorithm has improved the total system costs by ٨,٧٪ and has been able to perform better. As we can see in figure ٤, for the small dimension model, the Tabu search algorithm was ٤٪ better than the Harmony search algorithm. In the next level, in Table ٣, we examine ١٠ models in the medium dimension mode by using both Harmony search algorithms and Tabu search algorithms.

Table ٣: Total cost results in medium dimensions (Tabu search algorithm and harmony)

| | distribution $CO_2$ (ppm) | | Total price of chain | | Number of orders | Number of production | Sample |
|---|---|---|---|---|---|---|---|
| | Harmony | Forbidden | Harmony | Forbidden | | | |
| | ١٢٩٩ | ١١٧٨ | ٣٧٩٨٨٧ | ٣٧٥٩٩٥ | ٣١ | ٦ | ١ |
| | ١٣٦٨ | ١٢٠٨ | ٣٨٨٦٥٤ | ٣٧٩٥٥١ | ٣٥ | ٦ | ٢ |
| | ١٤٠١ | ١٣٢١ | ٤١٠٢١٤ | ٤٠٤١٢٤ | ٤٠ | ٧ | ٣ |
| | ١٤٣٣ | ١٣٤٢ | ٤٣٣٦٢٥ | ٤٢٣٥٥٤ | ٤٥ | ٧ | ٤ |
| | ١٦٨٧ | ١٥٧٤ | ٤٧٨٨٥٠ | ٤٦٨٥٩٦ | ٥٧ | ٨ | ٥ |
| | ١٧١٠ | ١٦٢٢ | ٥٠٢٣٢٧ | ٤٩٦٥٥٤ | ٦١ | ٨ | ٦ |
| | ١٧٨٨ | ١٧٠٠ | ٥٣٦٢٧٠ | ٥٢١٤٤٧ | ٦٥ | ٩ | ٧ |
| | ١٨٢٢ | ١٧٦٥ | ٥٦٩٩٨٥ | ٥٤٧٧٥٨ | ٧٠ | ١٢ | ٨ |
| | ١٩٩٧ | ١٩٣٢ | ٦١٢٣٥٢ | ٥٩٨٦٦٤ | ٧٥ | ١٤ | ٩ |
| | ٢٢٤١ | ٢١٢٠ | ٦٤٧٨٠٥ | ٦٣٥٩٧٥ | ٨٠ | ١٦ | ١٠ |

According to the results of medium dimensions, the Tabu search algorithm performed better than the Harmony search. Figures ٥ and ٦ indicate a graphical comparison of the results of both algorithms in medium dimensions.

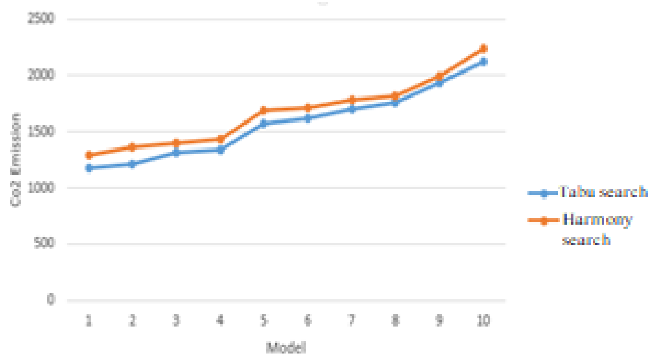


Figure ٦: Comparing carbon dioxide distribution by using two algorithms

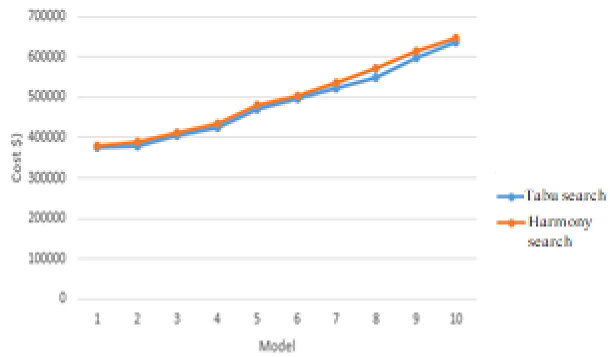


Figure ٥: Comparing total chain cost by using two algorithms

Considering the solution of the model in medium dimensions, the Tabu search algorithm has improved by ٦٪ compared to the Harmony search algorithm in order to determine the cost of the total supply chain. Also, comparing to Harmony search using the Tabu search algorithm carbon dioxide distributions have been improved by ٤,٥٪.

Finally, we solve the model in large dimensions in which the number of orders was between ٢٥٠ and ١٠٠٠ items. The results of the implementation of each algorithm are shown separately in Table ٤.

Table ٤: Total Cost Results in Large Dimensions (Forbidden and Harmony Search Algorithm)

| distribution $CO_2$ (ppm) | | Total price of chain(dollar) | | Number of order | Number of production | Sample |
|---|---|---|---|---|---|---|
| Harmony | Forbidden | Harmony | Forbidden | | | |
| ١٣٨٧٥ | ١٣٥٢٦ | ١٠٥٣٩٦ | ١٠١٢٥٤ | ٢٥٠ | ٢٠ | ١ |
| ١٤٠٠١ | ١٣٦٥٨ | ١١٨٦٣٦ | ١١٢٣٥٢ | ٣٠٠ | ٢٠ | ٢ |
| ١٤١٢٤ | ١٤٠٠٢ | ١٦٨٩٥٦ | ١٦٣٢٥١ | ٤٠٠ | ٢٥ | ٣ |
| ١٤٣٦٦ | ١٤٢٣٠ | ١٧٩٦٦٥ | ١٧٥٨٩٥ | ٥١٠ | ٣٠ | ٤ |
| ١٥٢٣٠ | ١٥٢٠٠ | ١٩٠٣٠٥ | ١٨٨٥٤٧ | ٦٠٠ | ٣٢ | ٥ |
| ١٦٩٩٥ | ١٦٢١٠ | ١٩٨٣٣٢ | ١٩٢٣٣٢ | ٦٥٠ | ٣٨ | ٦ |
| ١٧٩٨٥ | ١٦٨٩٠ | ٢٠٥٦٥٨ | ٢٠٢١١٤ | ٧٣٠ | ٤١ | ٧ |
| ١٨٥٥١ | ١٧٥٣٢ | ٢٢٠٣٣٢ | ٢١٨٧٧٤ | ٨٠٠ | ٤٥ | ٨ |
| ١٨٩٦٥ | ١٨٠٥٠ | ٢٣٢٠٨٢ | ٢٢٩٦٦٣ | ٩٠٠ | ٥٠ | ٩ |
| ٢٠٠٤١ | ١٩٨٥٠ | ٢٤٠٣٢٥ | ٢٣٦٥٦٢ | ١٠٠٠ | ٦٠ | ١٠ |

Figures ٧ and ٨ indicate a graphical comparison of the results of both algorithms in large dimensions.

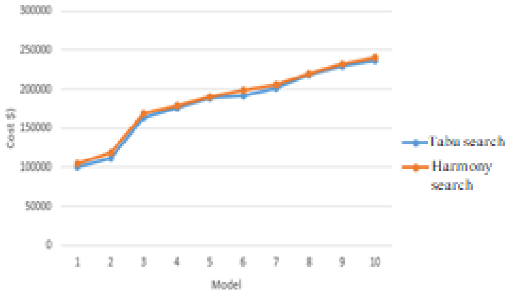


Figure ٧: Comparing total chain cost by using two algorithms

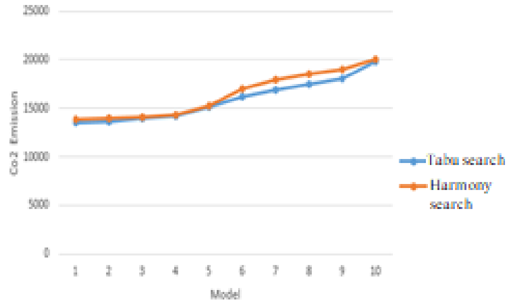


Figure ٨: Comparing carbon dioxide distribution by using two algorithms

According to the comparison of both algorithms for the large-scale model, it was noticed that the Tabu search algorithm with a ٢٪ improvement over the Harmony search algorithm has reduced the further cost of chain. Based on figure ٨, which shows the amount of carbon dioxide distributions obtained from the two algorithms, it is shown that the Tabu search algorithm has been effective in reducing the amount of distribution by ٢,٢٪.

### ٤-٣- Sensitivity Analysis

In order to analyze the sensitivity, we investigate the model for different dimensions, small, medium, and large. We examine the results obtained from Gomez, the Harmony search algorithm, and the Tabu search algorithm for carbon dioxide distribution and costs.

Table ٥: Cost and distribution results of $CO_٢$

| TS | | HS | | GAMS | | item | Dimension |
|---|---|---|---|---|---|---|---|
| price | distribution | price | distribution | price | distribution | | |
| ١١٥٥٠ | ١٤١٥٢ | ١٢٥٢٤ | ١٤٣٠٠ | ١٤٢١٢ | ١٦٥٥٢ | ٣ | small |
| ١٣٤٥٤ | ١٦٣٣٢ | ١٥٦٣٦ | ١٧٨٧٨ | ١٨٦٦٣ | ١٩٣٠٣ | ٦ | |
| ١٨٠٤٧ | ١٧١٢٠ | ١٩٩٨٥ | ٢٢٣٠٧ | ٢١٢٤٥ | ٢٥٦٦٣ | ٨ | |
| ٢٣٦٦٥ | ٢٠٣٥٢ | ٢٣٦٥٦ | ٢٥٥٨٨ | - | - | ١٢ | medium |
| ٢٤١٤١ | ٢٤٦٦٥ | ٢٦٨٥٩ | ٢٨٥٩٧٠ | - | - | ١٦ | |
| ٢٧٨٩٨ | ٢٦٦٨١ | ٢٩٩٨٧ | ٣٠٢١١٤ | - | - | ١٨ | |
| ٣٠٦٥٢ | ٢٨٩٦٨ | ٣٣٦٦٣ | ٣٢١٢٢٥ | - | - | ٢٠ | large |

| | | | | | | |
|---|---|---|---|---|---|---|
| ٣٤٨٧٥ | ٣٢٠٧٨ | ٣٦٨٧٤ | ٣٦٥٢٤٧ | - | - | ٢٤ |
| ٣٧٧٤٥ | ٣٤٥٨٥ | ٤٠٩٨٥ | ٣٨١١٢٤ | - | - | ٢٨ |

Now for comparison, we use the genetic algorithm for statistical and graphical comparisons in problems with different dimensions.

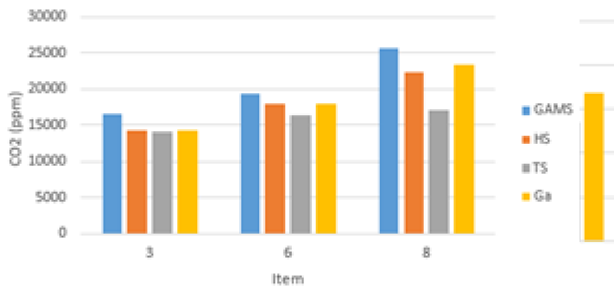


Figure ١٠: Comparison of carbon dioxide distribution results (small size)

Figure ٩: Comparison of cost results (small size)

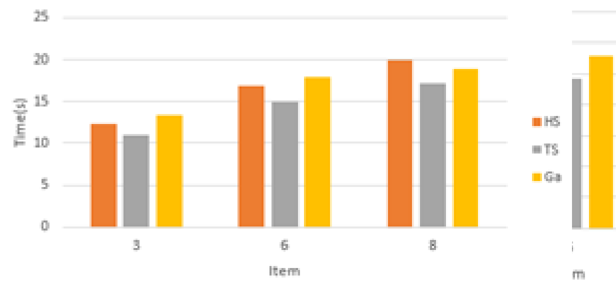


Figure ١٢: Comparison of carbon dioxide distribution results (medium dimensions)

Figure ١١: Comparison of cost results (average dimensions)

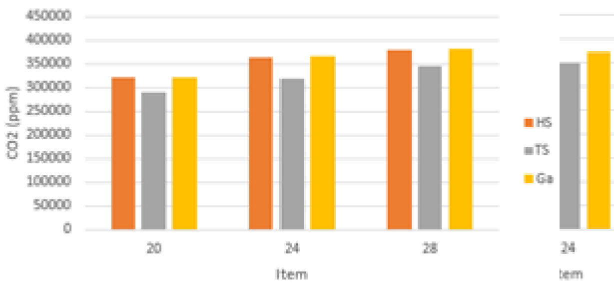


Figure ١٤: Comparison of carbon dioxide distribution results (large size)

Figure ١٣: Comparison of cost results (large dimensions)

The findings indicate the high efficiency of the Tabu search algorithm in both areas of distribution and price.

## ٥. Discussion and Conclusion

Considering the simulation performed and based on the result obtained from figure ١, it can be concluded that the convergence of the Harmony search algorithm after several repetitions of this algorithm on the specified functions and objectives. According to Figure ٢, which is the result of the Tabu search algorithm, by observing this result, we can conclude that we were able to achieve the best time and the best price between the server and the customer. The best mode created after ٢٥٠ repetitions will reach its best. In this research, meta-heuristic algorithms of Tabu search and Tabu search as well as genetics have been implemented, which have optimized the model answer in the output results. Finally, we have implemented the problem parameters in order to provide and solve a numerical example in Gomez software. Also, the sensitivity analysis of the input parameters of the problem reveals the effect of the parameters on the whole model. Sensitivity analysis was investigated in all three conditions of small, medium and large models by using the mentioned algorithms in MATLAB software and Gomez software; it should be noted that since the problem is NP-Hard type, medium and large dimensions cannot be implemented in Gomez software and only a small model was solved for this problem. It should be noted that the two cost criteria are gas distribution. Carbon dioxide was evaluated in all three methods and the results showed that the algorithms presented in MATLAB software had better performance than the model solved in Gomez software. On the other hand, the results indicate the high performance of the Tabu search algorithm compared to the Harmony search. In reviewing all the elaborated results, it is noticed that the Tabu search algorithm is better than the Harmony and genetic search algorithms because it causes the cost and time studied in this research to be optimized easily and under better and faster conditions.

**Practical Recommendation:**

- Considering a more appropriate criterion for calculating routing costs like: time, because there are conditions such as vehicle breakdown or traffic that do not express the cost of shipping per unit distance correctly.
- Providing supporting coverage for distribution centers so that goods are not accessible, it is possible to achieve the demanded goods from other distribution centers, including fines
- Considering direct transportation from the factory to the customer, if the customer has a high demand rate.
- Considering disrupting the capacity of machinery for reasons such as theft or attack, as well as disrupting the path that may because of natural disasters or pre-planned operations such as floods, earthquakes or unexpected events.

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