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Optimization algorithms for transportation problems with stochastic demand

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ABSTRACT

The purpose of this paper is to solve the stochastic demand for the unbalanced transport problem using heuristic algorithms to obtain the optimum solution, by minimizing the costs of transporting the gasoline product for the Oil Products Distribution Company of the Iraqi Ministry of Oil. The most important conclusions that were reached are the results prove the possibility of solving the random transportation problem when the demand is uncertain by the stochastic programming model. The most obvious finding to emerge from this work is that the genetic algorithm was able to address the problems of unbalanced transport, And the possibility of applying the model approved by the oil products distribution company in the Iraqi Ministry of Oil to minimize the total costs, Where the approved model was able to minimize the total costs by 25%. A future study investigating optimization heuristic with stochastics demand would be very interesting.

Keywords: Heuristic programming, stochastic linear programming, Optimization, chance constraints, genetic algorithms, probabilistic demand.

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1. Introduction

In recent years, there has been an increasing interest in the use of the heuristic algorithm in optimization problems and transportation models. Heuristics are algorithms that are used to find good, approximate solutions to difficult combinatorial problems that would otherwise be impossible to solve using existing optimization algorithms. A heuristic is a direct search technique that finds better solutions by applying favorable rules of thumb. Heuristics have the advantage of finding (good) solutions easily. The downside is that the solution's efficiency (in comparison to the optimum) is usually uncertain. The greedy search rule, which requires increasing the value of the objective function with each search move, was used in the early generations of heuristics. The search comes to a halt at a local optimum, beyond which no further advancement is possible. A new generation of metaheuristics emerged in the 1980s intending to improve the quality of heuristic solutions by allowing the search to avoid entanglement at local optima. Increased computations are required to realize the benefit. As well, Heuristic algorithms are used in solving transport optimization problems. The traditional transportation problem is a subset of linear programming problems in which the goal is to minimize the cost of transporting a product from some sources or origins to some destinations. The location to which shipments are delivered is referred to as the destination of a transportation problem. The objectives of this paper are to determine whether intelligent algorithms solve stochastic transportation problems. In recent years, there has been an increasing amount of literature on transport problems when demand is an uncertain environment [1]–[8]. In contrast, the research by Author indicated the use of heuristic optimization to solve the stochastic programming of the transportation model. It was the implementation of a well-known actual data set were the costs of transporting the gasoline product to the petrol Products Distribution Company of the Iraqi Ministry of Oil form 2021. The structure of this paper is divided into three main sections: the theoretical and

practical, and the conclusions reached through the analysis of the results of this research. The points of innovation this paper can be summarized as follows
1. Solving stochastic demand to transportation problems
2. Comparing the traditional method of linear stochastic programming with the genetic algorithm
3. Solving the problem of transporting and distribution of the Iraqi oil

2. Method

2.1. Transportation problem

The transportation problem gets rid of distributing a specific commodity from its supply center, which is called sources, to a group of reception centers, which are called destinations, in a way that minimizes the cost of the total distribution, as the goods are distributed from the source to his destination after determining the demand or the number of units by the exporter in order to be able to The destinations arrange this in a timely manner and bypass some of the problems that occur during the transport process, including the non-movement of the commodity or the goods directly, but rather passes through several transport points during the road, which disrupts the arrival of the goods to the distribution centers as well as the increase in the cost of transport, which leads to the failure of the transport process and failure Application of the model in addition to other problems that supply centers may face, which are the lack of clarity of demand by sources or the difference in supply from the quantity that was previously determined [4], [8]. Some companies may face the problem of transporting perishable items such as eggs and others, as this requires reducing fractions and reducing costs during the transportation process and trying to accomplish this in the shortest possible time without damaging the goods because increasing the speed may lead to an increase in the elements of breakage, and this is the biggest problem that may be exposed to it. What requires setting the important objectives required in the transportation process and transporting the goods in a suitable time and at an appropriate cost and the least losses for perishable goods. In this case, we may resort to reducing the total distance for such transport of such type of goods [1], [4], [5]. The transportation problem is a special type of operations research problem and it plays an important role in logistics and supply chains, the purpose of which is to minimize the cost of shipment of goods from one location to another or from one point to another to meet the arrival of needs (demand) in an appropriate time and cost without any problems during the transport process through Many methods are the most important and most prominent of these methods is the Vogel method, which depends on the penalty cost, which means the difference between the largest cost in the class and the largest cost in the column. the Mathematical model of the transportation problem [7], [9].

Minimize $Z = \sum_{i=1}^{n} \sum_{j=1}^{m} C_{ij} X_{ji}$

Subject To

$\sum_{i=1}^{n} xij \leq s$i i= 1,2,3,….,n (1)

$\sum_{j=1}^{m} xij \geq dj$ j= 1,2,3,….,m (2)

Where:
Cij: the transportation cost per unit
Si: display
dj: demand

2.2. Stochastic programming

Stochastic Programming is the basis for solving problems related to Uncertainty modeling. Whereas specific or confirmed modeling problems are formulated using known or confirmed parameters. Reality problems include some unknown parameters. If the parameters fall within certain limits, there is one way to solve this type of problem called robust optimization. The goal of random programming is to find an appropriate and optimal solution for all data. The stochastic programming models are similar in style but take into account the fact that the probability distributions that govern the data are known or can be estimated. The goal here is to find a suitable plan for all the data, and this plan predicts some random variables and decisions. Generally, these models are formulated and analyzed numerically to provide useful information for decision-makers or higher management. Stochastic programming is mathematical programming wherein it includes some target data or uncertain constraints. The uncertainty is usually characterized by the probability distribution of the parameters [2], [10], [11].

2.3. Probabilistic constraints models

Chance Constraint is one of the main methods for solving optimization problems under conditions of uncertainty or uncertainty, and it belongs to stochastic programming. The fitness problem model includes a probability constraint at a certain level. The applications of optimization under chance are very important, especially in the engineering, financial, and economic fields when the uncertainty in prices, demand, processing, exchange rate, recycling, as well as traditional applications such as management of water storage and financial risk management as well as used in the fields of renewable energy. The chance constraint is defined as a modified constraint in which the right-hand side is random (and it can also be defined as within the stochastic programming method). or achieving a certain probability level as a vector of chance (Stochastic Vector) imposes on a system of constraints optimization problems in the case of decision-making [3], [6], [7], [12], [13].

2.4. Mathematical model

The mathematical model for stochastic variables for the optimization problem under uncertainty takes the following mathematical form [3], [4], [6]–[8]:

$$p\{\sum_{j=1}^{n} aij\ xj \leq \mathrm{bi}\} \geq \alpha \qquad (3)$$

That is, it requires the original constraint which is:

$$\sum_{j=1}^{n} aij\ xj \leq \mathrm{bi} \qquad (4)$$

The general appearance of these models is as follows:

Z=MAX ($\sum$cjxj)

S.T

$$p(\sum_{j=1}^{n} aij\ xj \leq bi) \geq \alpha i\ \ for\ i = 1 \ldots.m \qquad (5)$$

Xj ≥ 0 for j=1…n

Linearity under chance:

If we have the distribution function (cdf):

Fi (y) = P (bi ≤ y)

A chance constraint is equivalent to:

$$\mathrm{p}\,\{\sum_{j=1}^{n} aij\ xj \leq bi\} = 1 - p\{bi \leq \sum_{j=1}^{n} aij\ xj\} = 1 - Fi\ \ \{\sum aijxj\} \qquad (6)$$

i.e.., 1-Fi{$\sum$aijxj} ≥ α

or

$$\mathrm{Fi}\,\{\sum_{j=1}^{n} aij\ xj\} \leq 1\text{-}\alpha \qquad (7)$$

but:

$$\mathrm{F1}\,\{\sum_{j=1}^{n} aij\ xj\} \leq 1\text{-}\alpha \leftrightarrow \mathrm{F}_1^{-1}\quad (1\text{-}\alpha) \geq \sum_{j=1}^{n} aij\ xj \qquad (8)$$

The inequality in the right is linear

2.5. Intelligence algorithm

Genetic algorithm is considered the very important and most popular algorithms in artificial intelligence. The genetic algorithm (GA) simulates the biological evolution process of "survival of the fittest." Each possible solution to a problem is thought of as a chromosome encoded by a set of genes. Binary (0, 1) and numeric gene codes are the most common. A population with N chromosomes is a set of N feasible solutions. A chromosome's fitness is measured in terms of an appropriate objective function. A better-fitting chromosome produces a higher value of the objective function. The general idea behind GA is to choose two parents from a population. The actual implementation of GA necessitates the inclusion of additional problem-specific details. Furthermore, the rules for choosing parents and having children may differ. The transportation problem is one of the linear improvement problems that seeks to find an optimal solution, and evolutionary algorithms, particularly the genetic algorithm, are one of the most important modern methods used to improve the solution of transport problems to achieve the best possible results and achieve the institution's or company's goal as quickly as possible. Figure 1 illustrates the Genetic algorithm methodology [13]–[15-17].

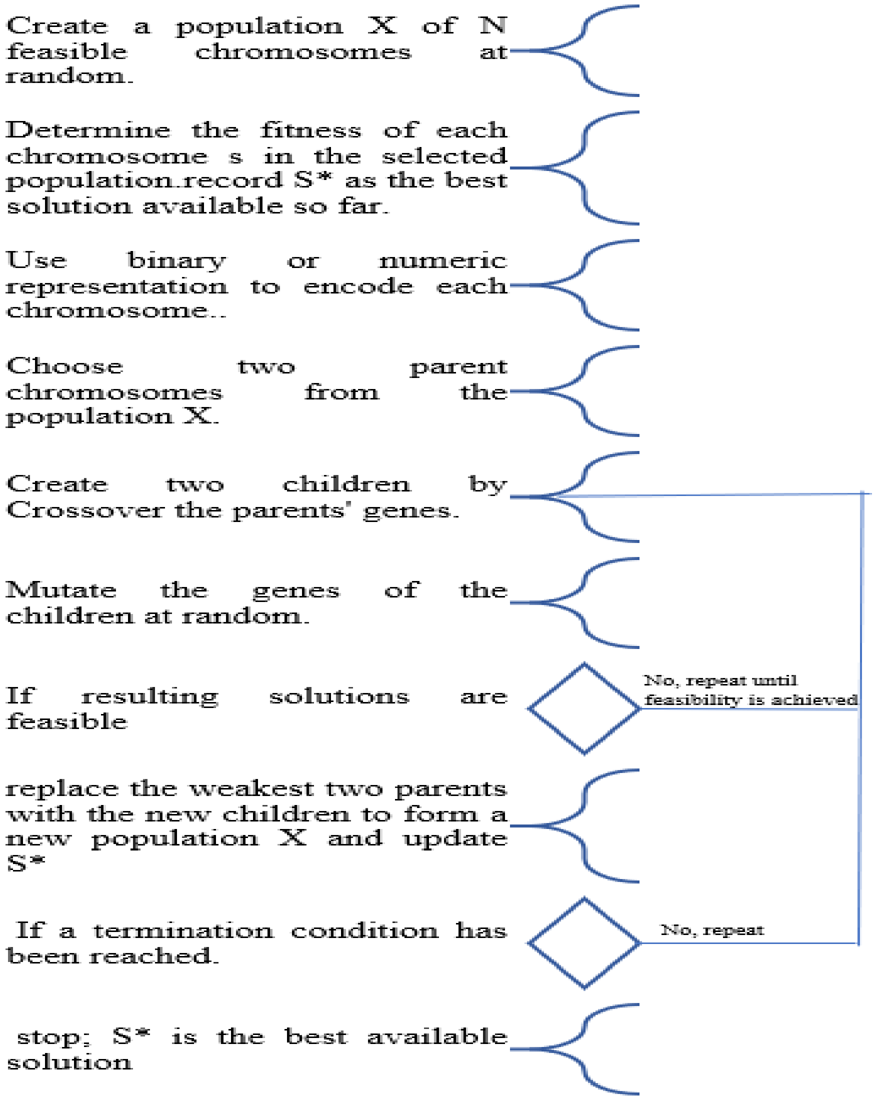

Figure 1. Methodology of Genetic algorithm

3. Results and discussion

Table A1 presents data costs for transporting the gasoline product from three warehouses to six main fuel filling stations for the Oil Products Distribution Company in the Iraqi Ministry of oil for the year 2020.

Table 1. shows the costs of transporting the gasoline product from the warehouse to the station

Stations / Warehouses	S1 (almathnaa)	S2 (AlMansour)	S3 (AlMustansiriya)	S4 (AlIdrisi)	S5 (AlKilani)	S5 (albnuk)	supply
D1 (aldawruh)	836	1097	1202	1254	1045	1620	440
D2 (alkarkh)	560	2717	2926	3396	2665	3762	504
D3 (alrusafa)	508	2874	1855	1515	1672	1881	560
Demand	D1	D2	D3	D4	D5	D6	

the values of di in Table (2),i=1,2,3,4,5,6

Table 2. It shows the values of the demand

demand	D1	D2	D3	D4	D5	D6
1	140	250	160	140	260	120
2	155	260	153	143	255	110
3	146	255	165	145	259	115
4	162	259	169	156	261	118
5	154	262	159	156	265	125
6	159	260	154	152	254	129
7	149	259	152	154	268	124
8	160	258	156	146	259	119
9	164	266	158	148	253	116
10	153	265	159	149	257	125
11	150	261	162	146	269	128
12	164	258	167	142	261	116
13	163	263	168	141	263	113
14	169	257	163	147	267	124
15	158	256	165	159	264	128
16	151	268	164	153	261	123
17	149	269	167	156	256	117
18	146	262	160	154	258	113
19	142	265	150	158	257	112
20	147	258	162	157	261	114
21	146	251	158	158	264	120
22	158	269	157	152	268	127
23	162	266	169	142	255	110
24	157	255	163	141	255	128
25	146	254	162	151	266	126
26	149	262	151	156	257	119
27	153	267	150	153	251	126
28	159	256	158	149	261	128
29	157	251	162	148	264	124
30	152	259	161	147	259	126

Figure 2 shows the Goodness of Fit Test results was used to determine the order's distribution through the statistica program, and the test results indicated that the order followed the normal distribution, as shown in the following figure:

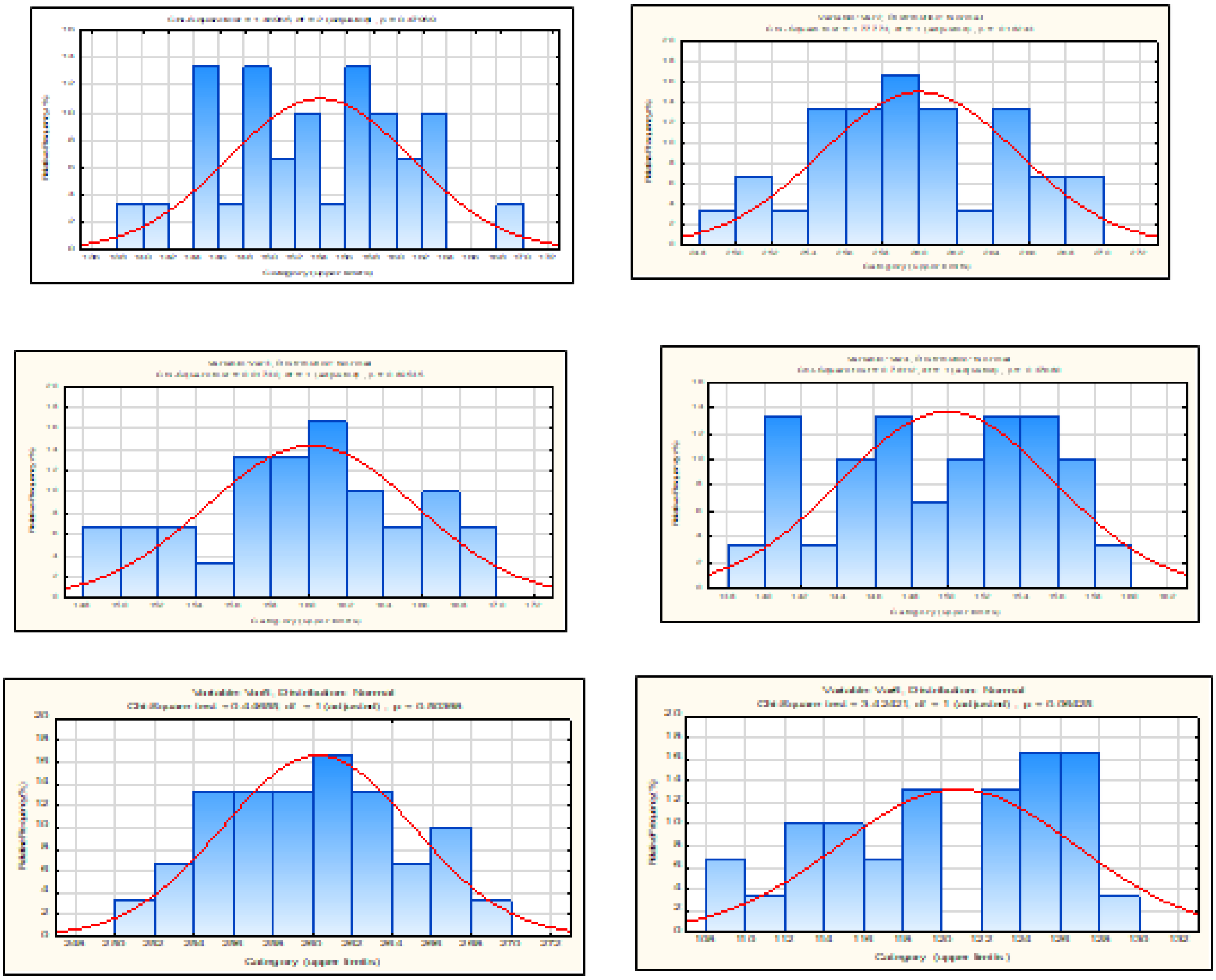

Figure 2. The results of the conformity test for the six demand variables

Based on formula (1, 2) with a significant level of 2.5%, the mathematical formula for the transportation problem is as follows:

Min Z=836 X11+1097 X12 +1202 X13 +1254 X14 +1045 X15 +1620X16 +560 X21 + 2717X22 + 2926 X23+3396 X24 + 2665 X25 + 3762 X26 +508 X31 +2874 X32+1855 X33 +1515 X34 + 1672 X35 +1881X36

SUBJECT TO

836 X11+1097 X12 +1202 X13 +1254 X14 +1045 X15 +1620X16 $\leq$ 440
560 X21 +2717X22 + 2926 X23+3396 X24 + 2665 X25 + 3762 X26 $\leq$ 504
508 X31 +2874 X32+1855 X33 +1515 X34 +1672 X35 +1881X36 $\leq$ 560
836 X11 + 560 X21 + 508 X31 $\geq \mu_{D1} - 1.96\sigma_{D1}$
1097 X12+ 2717 X22 + 2874 X32 $\geq \mu_{D2} - 1.96\sigma_{D2}$
1202 X13+2926 X23 +1855 X33 $\geq \mu_{D3} - 1.96\sigma_{D3}$
1254 X14 + 3396 X 24 +1515 X34 $\geq \mu_{D4} - 1.96\sigma_{D4}$
1045 X15 +2665 X25 +1672 X35 $\geq \mu_{D5} - 1.96\sigma_{D5}$
1620 X16+ 3762 X26 + 1881 X36 $\geq \mu_{D6} - 1.96\sigma_{D7}$
And All X $\geq$ 0

Min Z=836 X11+1097 X12 +1202 X13 +1254 X14 +1045 X15 +1620X16 +560 X21 + 2717X22 + 2926 X23+3396 X24 + 2665 X25 + 3762 X26 +508 X31 +2874 X32+1855 X33 +1515 X34 + 1672 X35 +1881X36

SUBJECT TO

836 X11+1097 X12 +1202 X13 +1254 X14 +1045 X15 +1620X16 $\leq$ 440

$560 X21 + 2717X22 + 2926 X23 + 3396 X24 + 2665 X25 + 3762 X26 \leq 504$
$508 X31 + 2874 X32 + 1855 X33 + 1515 X34 + 1672 X35 + 1881X36 \leq 560$
$836 X11 + 560 X21 + 508 X31 \geq 140$
$1097 X12 + 2717 X22 + 2874 X32 \geq 250$
$1202 X13 + 2926 X23 + 1855 \geq 149$
$1254 X14 + 3396 X 24 + 1515 X34 \geq 139$
$1045 X15 + 2665 X25 + 1672 X3 \geq 251$
$1620 X16 + 3762 X26 + 1881 X36 \geq 109$
And All $X \geq 0$
The model was solved using Matlab using a genetic algorithm, and the results are as follows

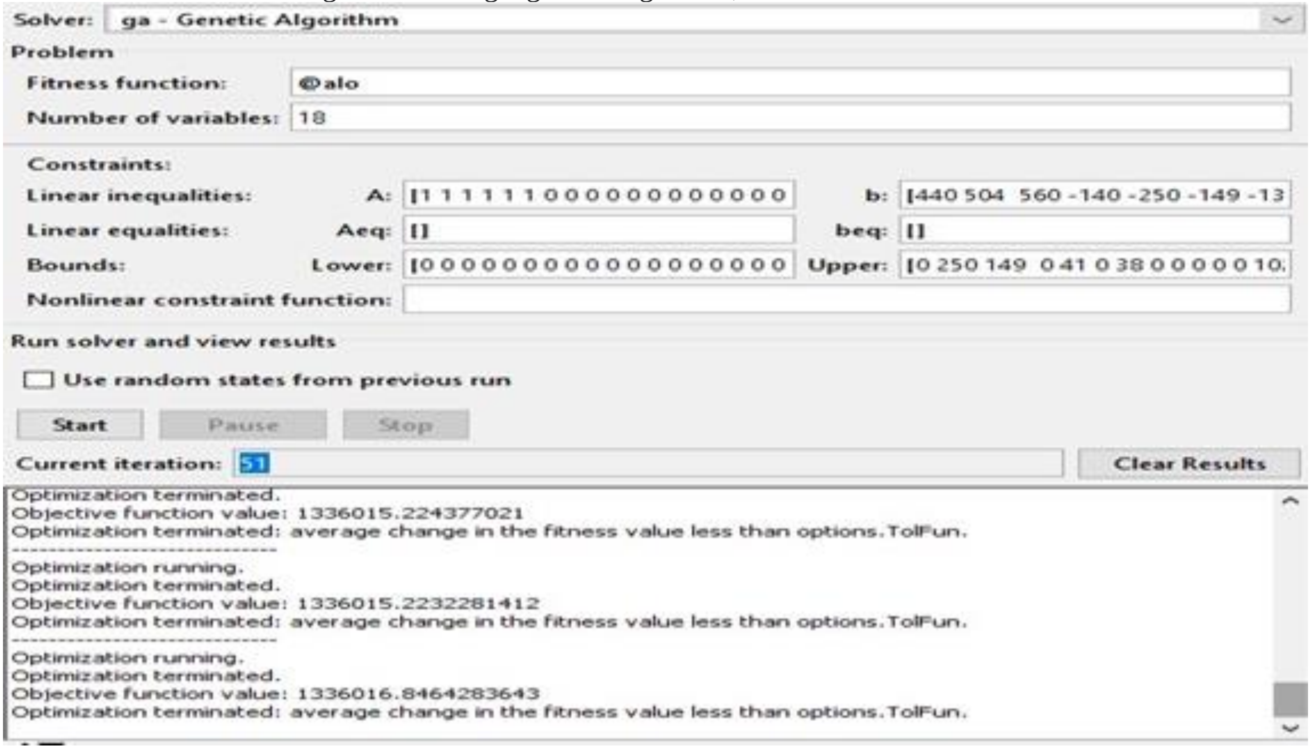

Figure 3. Results of genetic algorithm

The number of periods of the genetic algorithm is (51) periods and that the final cost of transporting the gasoline product is (1336016) dinars is shown in Figure 3.

4. Conclusions

The following conclusions were obtained:

- The results prove that the demand represents a random variable that follows the normal distribution and at a certain rate and variance
- The results also show that the possibility of solving the random transportation problem if the demand is unknown through the random programming model.
- Based on the results, the genetic algorithm was able to address the problems of unbalanced transport
- The results reveal that the final cost of transporting the gasoline product from the main warehouses to the fuel filling stations is (1336016) dinars, which is 25% less than the costs approved by the company.

Declaration of competing interest
The authors declare that they have no any known financial or non-financial competing interests in any material discussed in this paper.

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References

[1] M. P. Biswal and H. Samal, “Stochastic transportation problem with cauchy random variables and multi choice parameters,” 2013.

[2] S. K. Barik, M. P. Biswal, and D. Chakravarty, “Stochastic programming problems involving pareto distribution,” J. Interdiscip. Math., vol. 14, no. 1, pp. 40–56, 2011.

[3] A. Pradhan and M. P. Biswal, “Multi-choice probabilistic linear programming problem,” Opsearch, vol. 54, no. 1, pp. 122–142, 2017.

[4] S. K. Roy and D. R. Mahapatra, “Solving solid transportation problem with multi-choice cost and stochastic supply and demand,” Int. J. Strateg. Decis. Sci., vol. 5, no. 3, pp. 1–26, 2014.

[5] D. R. Mahapatra, S. K. Roy, and M. P. Biswal, “Stochastic based on multi-objective transportation problems involving normal randomness,” Adv. Model. Optim., vol. 12, no. 2, pp. 205–223, 2010.

[6] M. A. Lejeune and F. Margot, “Solving chance-constrained optimization problems with stochastic quadratic inequalities,” Oper. Res., vol. 64, no. 4, pp. 939–957, 2016.

[7] L. Bertazzi, A. Bosco, and D. Laganà, “Managing stochastic demand in an inventory routing problem with transportation procurement,” Omega, vol. 56, pp. 112–121, 2015.

[8] K. Holmberg and H. Tuy, “A production-transportation problem with stochastic demand and concave production costs,” Math. Program., vol. 85, no. 1, pp. 157–179, 1999.

[9] Ashour, Marwan Abdul Hameed, Alyaa Abdulameer Ahmed, and Iman Amer Hameed Al-dahhan. "Minimizing Costs of Transportation Problems Using the Genetic Algorithm." In Proceedings of Sixth International Congress on Information and Communication Technology, pp. 165-173. Springer, Singapore, 2022.

[10] M. A. Hameed, I. A. H. Al-Dahhan, and A. K. Hassan. "Forecasting by using the optimal time series method." In International Conference on Human Interaction and Emerging Technologies, pp. 148-154. Springer, Cham, 2020..

[11] M. A.. "Optimum cost of transporting problems with hexagonal fuzzy numbers." Journal of Southwest Jiaotong University 54, no. 6, 2019

[12] A. M. A. Hameed, Optimized Artificial Neural network models to time series. Baghdad Sci.J [Internet]. [cited 2022Apr.15];19, no. 4, 2022.

[13] S. N. Al-Saadi and K. S. Al-Jabri, “Optimization of envelope design for housing in hot climates using a genetic algorithm (GA) computational approach,” J. Build. Eng., vol. 32, p. 101712, 2020.

[14] M. A. H. Ashour, I. A. H. Al-Dahhan, and S. M. A. Al-Qabily, “Solving Game Theory Problems Using Linear Programming and Genetic Algorithms,” in Human Interaction and Emerging Technologies, pp. 247–252, 2020.

[15] A. S. Hussein, R. S. Khairy, and S. M. M. Najeeb, "Credit Card Fraud Detection Using Fuzzy Rough Nearest Neighbor and Sequential Minimal Optimization with Logistic Regression," International Journal of Interactive Mobile Technologies, vol. 15, no. 5, 2021.

[16] H. T. ALRikabi and H. T. Hazim, "Enhanced Data Security of Communication System Using Combined Encryption and Steganography," International Journal of Interactive Mobile Technologies, vol. 15, no. 16, 2021.

[17] S. G. Ponnambalam, P. Aravindan, and G. M. Naidu, “A multi-objective genetic algorithm for solving assembly line balancing problem,” Int. J. Adv. Manuf. Technol., vol. 16, no. 5, pp. 341–352, 2000.