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| RESEARCH ARTICLE

Using a Fuzzy Genetic Algorithm for Solving Transportation Logistics Problems

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| ABSTRACT
Recently, Science defined transportation as the most potent component of logistics. In addition, it has an interdependent relationship with business logistics. Also, AI is intervened in transportation logistics to solve transportation issues. Also, it is used for optimizing and obtaining possible solutions for critical and complex problems. This paper aims to optimize costs and profit to get satisfaction for individuals and organizations using AI techniques. A proposed methodology consisted of two phases. The first phase discusses data collection, and the second involves applying FGA Artificial Intelligence techniques. A proposed Transportation Logistics model was used to determine boundary profit for each Product, and a Fuzzy Genetic Algorithm FGA for transportation logistics was done to solve transportation issues. According to that, outcomes were detected by optimizing the transportation cost by detecting the parent's and the child's chromosomes, and it took the number of iterations =2000. Also, between 100 loops, the best of 5 loops took 1.53 Millie seconds per loop Using GA. Similarly, GA was used for optimizing the minimum total cost of the Product also by determining parents and child chromosomes, which took the Number of iterations= 2000, and among 100 loops, the best five loops took 1.40 ms per loop. Moreover, determining the profit boundary of each predicted Product using triangular fuzzy logic shows that the minimum profit is considered between (20 million and 23.9 million), while the moderate profit is (24 million), and the maximum profit is more than (24.1 million).

| KEYWORDS

Fuzzy Genetic Algorithm, Genetic Algorithm, Fuzzy Logic, Triangular Fuzzy Logic, Logistics, Transportation, AI, BI, FGA.

| ARTICLE INFORMATION

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1. Introduction

Business Intelligence (BI) has recently been described as creating future predictions and making decisions easier in the business sector. To do that, it needs to perform data analysis using a specific system which is known as Business information systems (BIS). That is used in visualizing BI for directors. BIS has various zones of usage, relying on the purposes of the processes and the data that is produced (Svenson, 2020). In recent years BI has been considered the most important zone in AI that is used in transforming all business sectors into intelligence sectors using AI techniques.

Artificial Intelligence has become the leading novel in several types of business. With AI, any organization can exchange the human element with a technological expert system, as shown in figure 1 (Svenson, 2020). Significant progress and evolution in the development of AI algorithms have happened to decide the optimum decisions and effective solutions for multiple issues, as shown in figure 2 (white-paper-artificial-intelligence-in-logistics, 2021).

On this hand, AI was intervening with logistics in multiple zones, such as "solving issues in managing stream of information and products, stocking, and especially in solving problems multimodal in transportation ". So, transportation has become the main category and the most powerful component in the logistics business (Rondeau T. W. et al., 2005). This way, we can inform that logistics management will not succeed without successful transportation management. Also, this will not be achieved without using artificial intelligence techniques.

This paper is focused on how to integrate two areas of AI Techniques, "Fuzzy logic and genetic algorithm techniques," to solve multimodal and multi-complex problems in transportation logistics by applying a proposed Transportation Logistics model for determining boundary profit in transportation logistics based on the Proposed Fuzzy Genetic Algorithm "FGA."

Paper organization. Section II briefly explains the research background. Section III explains the research methodology. Section IV explains the proposed model. Section V explains the proposed Algorithm. Section VI illustrates the results of the research. And section VII provides the conclusion and recommendation.

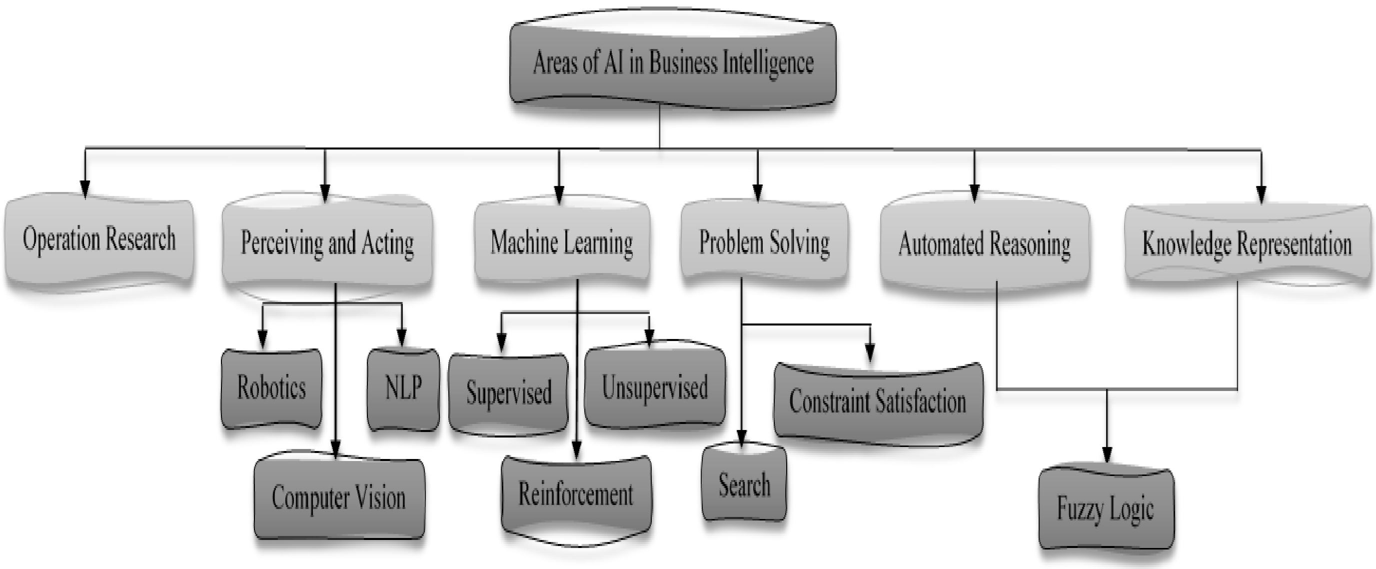

Figure 1AI Areas in Business Intelligence (BI).

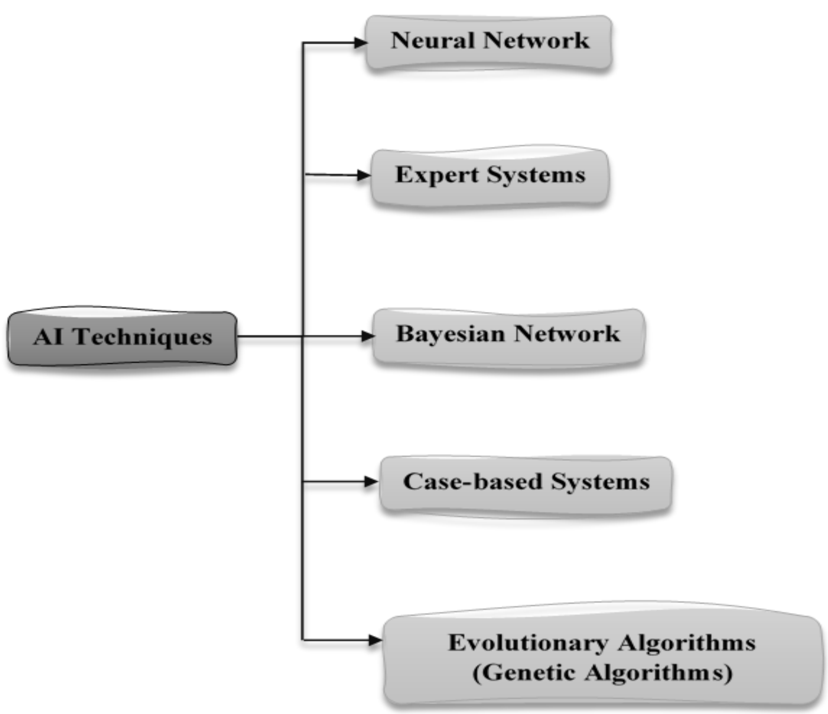

Figure2 Evolutions of AI

2. Literature Review

In the recent past, many articles and papers concentrated on transportation logistics optimization in different zones, such as "management, business, Accounting, and Economics." Recently, research was going ahead on how to make logistics more powerful using AI techniques. So, this section will define some articles that spot the light on GA and Fuzzy logic techniques in transportation logistics as follows and also make a comparative study for each study.

A review paper by (Mazin Abed Mohammed et al.; 2014) focused on Vehicle Routing Problem (VRP). On this hand, the author concluded that GA could solve this issue more efficiently. Moreover, these kinds of issues were considered under the optimization problems.

Similarly, (Helong Wang et al.; 2017) proposed a model to optimize ship motor strength to decrease fuel and air rebirth. Also, dynamic programming and GA were combined to minimize fuel exhaustion and air rebirth.

Likely, in determining the optimization area, (A.Serban, 2021) analyzed deviations from the mapping schedule for the train line in "Bucharest city." The author builds his optimization model by mapping a schedule in several "nodes, times of the day, and days of the week" to build his optimization model. So, the author collected several data to achieve a large number of solutions using GA. Moreover, (Andrii Shekhovtsov et al.; 2020) made two new approaches to detect specific and standard decisions to solve transportation issues using fuzzy logic. The authors make a case study and test and evaluate its results by detecting the relationship between each criterion using multiple techniques. Also, they assess the effectiveness of each criterion using multicriteria decision analysis techniques.

Besides, (Aurora Nur Aini et al.; 2021) showed that transportation problems were classified under fuzzy logic. Also, transportation issues are a specific case for linear programming. The authors imply that they can solve these issues by converting the fuzzy number into a crisp number by ordering the fuzzy number. In addition, the authors showed that there were many applicable methods to solve linear transportation problems.

Table I Literature review comparative study.

Ref. no	Year	Algorithm Used	Data Scope	Results
[4]	2017	GA	Vehicle routing problem VRP	The authors concluded that VRP is an issue that can go under optimization problems using GA
[7]	2020	FL	Transportation issues	The authors Build two approaches for detecting a specific and a standard decision
[5]	2021	GA	Optimize ship motor strength	Authors make a proposed model used to decrease the fuel and air rebirth
[6]	2021	GA	Mapping schedule for trainline	The author maps a schedule for the trainline in several nodes. Also, achieve several solutions of nodes.
[8]	2021	FL	Transportation	Authors concluded that transportation issues were considered Fuzzy Logic and a linear programming problem only

According to the above comparison, there is a new zone that our paper focuses on it to be used in transportation optimization issues, which is the Fuzzy Genetic Algorithm "FGA". To solve multi-complex transportation issues. Depending on that, we can inform you that our main objective is optimizing profit for companies using FL and minimizing costs for clients using GA, as shown in table I.

3. Methodology

3.1 Logistics based on AI Techniques

a). Genetic Algorithm: GA is a heuristic search to detect the nearest optimum solution. In addition, it uses techniques that were inspired by evolutionary biologies, like "selection, mutation, and crossover" (*Genetic Algorithms (GAs), 2021)*. According to this, in our paper, a population will be realized to compute the fitness of everyone in the population. Moreover, it optimizes costs for individuals and optimizes profits for organizations.

- *Triangular Fuzzy Logic*: A triangular membership is a function assigned by three parameters like {L, M, U}.

Triangle $(X, L, M, U) = 0\ if\ x \leq L$ Triangle $(X, L, M, U) = (X - L)/(M - L)\ if\ L \leq x < M$; $Triangle\ (X, L, M, U) = (U - X)/(U - M)\ if\ M < x \leq U$; Triangle $(X, L, M, U) = 0\ if\ U \leq X$; Eq.(1)

as shown in FGA Algorithm "Algorithm 1".

So, depending on this theory, the usage of triangular fuzzy logic will be powerful for detecting if the profit of any organization is "low profit or moderate profit or maximum profit".

b) Phase1: Data Collection

In this phase, the dataset will be defined. Then, products will be classified according to their types and costs.

Moreover, costs will be divided into fixed, variable, internal, external, depreciation, and Prices.

In addition to all those categories, transportation cost and total cost for each Product will be computed as shown in figure 3[10].

c). Phase2: Applying FGA Artificial Intelligence Technique

Calculate transportation cost; then apply the GA technique to achieve the nearest optimum solution, In addition to detecting the minimum transportation costs. After that, calculating the total cost for each Product to be useful for predicting the optimum solution using GA, as shown in figure 4. After all, compute the profit for each Product using triangular fuzzy logic to get the boundary profit. Finally, the analysis is used to measure if prices influence each Product's demand and supply. Moreover, achieving satisfaction for clients and companies through minimizing costs and maximizing profit is shown in figure 5.

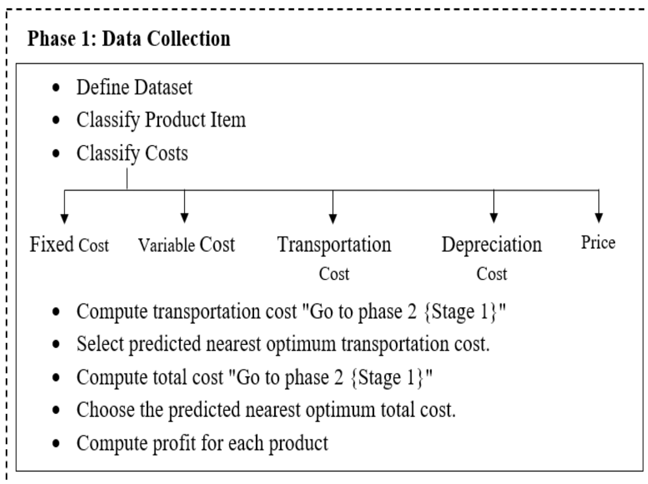

Figure 2 Research Methodology Phase1.

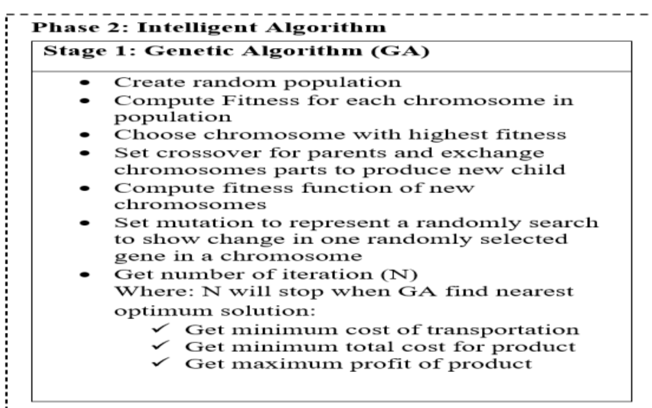

Figure 3Research Methodology phase2_stage1

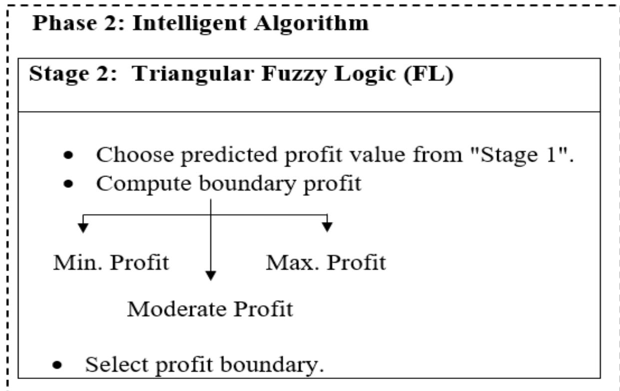

Figure 4 Research Methodology phase2_stage2

4. Proposed Transportation Logistics Model

The paper's main goal is to optimize profit for each Product. An enhanced model will be constructed and discussed in seven steps, as shown in figure 6.

Step 1. Gathering information.

Dataset collected from the Egyptian portal for transportation from the year "2014" to the year "2020".

Step 2. Define datasets that will be used.

Prices for both consumers and products were defined by using Pandas for reading dataset.csv.

Step 3. Classify product items and costs.

Data learning, data transformation, and feature selection were made to pick correlated columns using visualization libraries matplotlib and seaborn.

Step 4. Compute internal costs, external costs, transportation costs, total costs, and profit for each Product.

Using stat and SciPy libs for statistics using NumPy lib for transforming the selected features to a 2D array, In addition to getting transportation costs, total costs, and profit.

Step 5. Find the nearest optimum solution for the above situations using GA, which are:

- Transportation costs (get minimum costs).
- Total costs (get minimum costs) for each Product.
- Profit (get maximum profit) for each Product.
-

Step 6. Get the boundary profit value of each Product using triangular fuzzy logic. Using SKFUZZY to compute the fuzzy triangular for products.

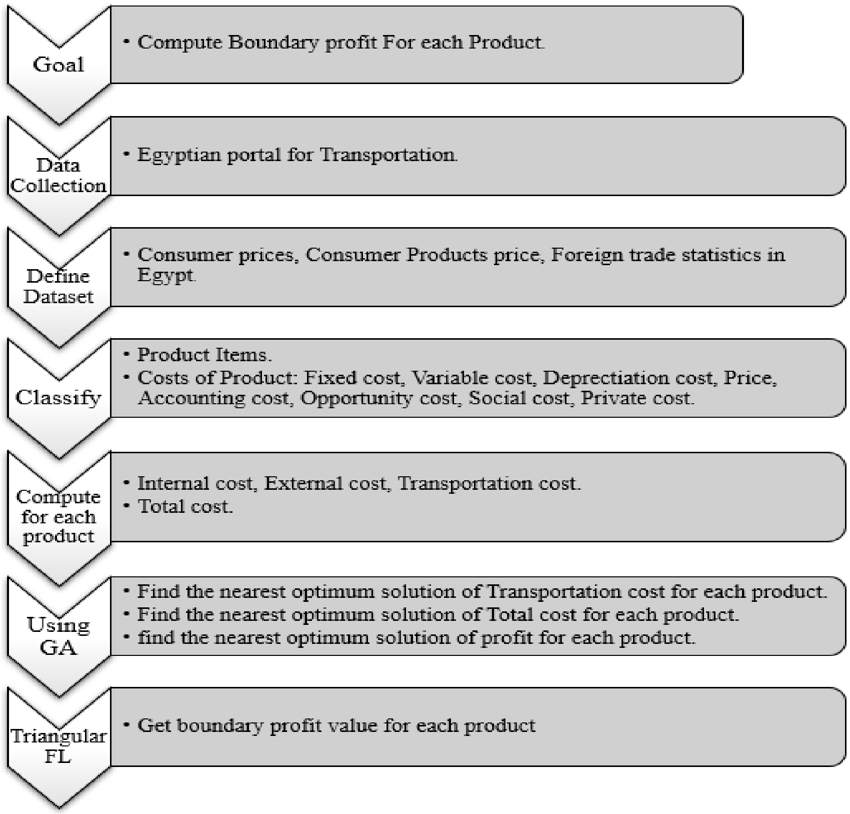

Figure 5 A Proposed Transportation Logistics model for Determining boundary profit for each Product.

5. Proposed Fuzzy Genetic Algorithm (FGA)

A proposed Algorithm was added to the algorithm of "Genetic Algorithm for Transportation logistics" (Emam, O., 2021) to solve complex transportation logistics problems using AI techniques, in addition to obtaining both "Customers and Organizations" satisfaction. Besides determining the boundary profit value for each Product, Simultaneously check whether the predicted Product is useful for Egyptian marketing or not. The FGA algorithm is used to know if it can gain "Maximum, Moderate, or Minimum" profit for organizations. Moreover, to optimize transportation costs and total costs to gain customer satisfaction. The proposed algorithm "FGA" consists of five steps. Each step is used to compute a specific cost. Also, to determine the minimum transportation cost and the minimum total cost.

- The first step is conducted to know how to compute the transportation cost via specific parameters, which are (Accounting costs "ACC", Opportunity costs "OPC"), to get the Internal costs "IC". Also, determined (Social Costs "SC", Private Costs "PC") to get the External Costs "EXC"; as well as to get the transportation costs by adding the internal cost to the external cost.

- The second step is used to optimize the nearest optimum solution using GA to get the minimum Transportation cost. Also, getting the minimum total cost was dependent on the results of optimizing the transportation cost.

- The third step is used to compute the total cost, as shown in algorithm 1. Total cost "tc" = the summation of Average Fixed Cost "AVG.FC" and the Average of Variable Cost "AVG.VC". After that, multiply the result by the quantity" Q".

- The fourth step is used to compute the Maximum profit for each element by determining the Total Revenue "TR" in which TR equals the multiplication of Price and Quantity; Then, compute the profit "PR" by obtaining the difference between the "TR" and the "tc".

- The fifth step describes how to compute the boundary profit using the triangular fuzzy logic theory. Which "L" refers to Lower profit, "M" refers to Moderate profit, and "U" refers to Upper profit, as shown in Algorithm 1.

Algorithm1: FGA Algorithm for transportation logistics.

Input: Fixed cost, Variable cost, Transportation cost, Depreciation cost, Price.
Output: Determine boundary profit for each Product.
Procedure:

Step 1: Compute TC for each Product.

- $\text{IC}= \sum(\text{ACC}, \text{OPC})$

  Where IC= Internal Cost
  ACC= Accounting Costs
  OPC= Opportunity Costs
- $\text{EXC}= \text{SC} + (-\text{PC})$

  Where EXC= External Cost
  SC= Social Costs
  PC= Private Costs
- $\text{TC}= \sum(\text{IC}, \text{EXC})$

  Where:
  TC= Transportation Cost
- Get a minimum of TC for each product "Go to step 2".

Step 2: Find the nearest optimum solution using GA.

- Produce a random initial population.
- Compute Fitness for each chromosome in the population

  Where:
  $\text{f(x)c}= \frac{\textbf{Chromosome fitness}}{\sum_i^N \textbf{Chrom fitness}}$
  f(x)c= Fitness function of Chromosome in population
- Choose the chromosome with the highest fitness.
- Set crossover for parents and exchange chromosome parts to produce a new child.
- Compute the Fitness function of new chromosomes

  Where:
  $\text{f(x)nc}= \frac{\textbf{Chromosome fitness}}{\sum_i^N \textbf{Chrom fitness}}$
  f(x)nc= fitness function of new chromosome
- Set mutation to represent a random search to present change in one randomly selected gene in a chromosome.
- Stop N when GA finds the nearest optimum solution.

  Where:
  N= Number of Iteration

Step 3: Compute the total cost for each Product.

- $\text{tc}= \sum((\text{AVG. FC}), (\text{AVG. VC})) \times \text{Q}$

  Where tc= total cost
  AVG. FC= Average of Fixed Cost
  AVG.VC= Average of Variable Cost
  Q= quantity
- Go to step2 to get the nearest optimum solution of minimum tc for each Product.

Step4: Go to step 2 to find the maximum profit for each Product.

- $\text{TR}= \text{P} \times \text{Q}$
- $\text{PR}= \sum(\text{TR}(-\text{tc}))$

  Where: TR= Total Revenue
  PR= Profit
  P= Price
  Q= Quantity

Step5: Compute boundary profit value using Triangular Fuzzy Logic

- $$\mu_A(x) = \begin{cases} \frac{x-L}{M-L} & if\ L \le x < M \\ 1 & if\ x = M \\ \frac{U-x}{U-M} & if\ M < x \le U \\ 0 & if\ otherwise \end{cases}$$

Where: L= lower value
M= Center Value
U= Upper Value

- Select boundary profit.

End Procedure

6. Results

Dataset was collected from the Egyptian portal for transportation from the year 2014 to the year 2020. Moreover, it consists of three main types: Land Lines, Marine Lines, and Air Lines. The consequences derived from this paper have consisted of multiple stages:

Before describing those stages, we must do data cleaning for our dataset to delete the outliers before implementing it. In addition to outcomes, a perfect correlation using the heatmap tool and description for the dataset is done, as shown in tables II, III, IV, and figure 7, to make results more accurate.

Table II Dataset before Data Cleaning

	DC/P	SC/P	PC/P	EC/P	AC/P	OC/P	IC/P	Q_Kilo
Products								
Beans_F_D	738000.0	10011000	3000000	7011000	4011000	3000000	7011000	10000
Beans_F_D	1230000.0	4000000	2600000	1400000	9130000	3000000	12130000	10000
Beans_F_D	492000.0	11000000	4000000	7000000	4000000	3268000	7268000	10000
Cheese	576000.0	10000000	5000000	5000000	2000000	1064000	3064000	10000
Cheese	864000.0	6000000	2112000	3888000	3000000	888000	3888000	10000
...	...	...	...	...	...	...	...	...
Tomatoes	213000.0	2000000	1000000	1000000	1000000	662500	1662500	10000
Tomatoes	124250.0	5000000	2000000	3000000	2000000	1212500	3212500	10000
Wheat_flour	160080.0	4000000	2000000	2000000	1002000	1000000	2002000	10000
Wheat_flour	200100.0	2000000	1000000	1000000	1000000	501250	1501250	10000
Wheat_flour	116725.0	3000000	1000000	2000000	2000000	1836250	3836250	10000

378 rows × 8 columns

- Stage 1: Transportation Cost calculations for each Product

According to this stage, we must determine all types of Transportation, the internal costs (Accounting cost, Opportunity cost), and External costs (Social costs, Opportunity cost) for each Product to be computed as shown in table V.

$$IC = \sum (ACC, OPC) \quad \text{Eq. (2)}$$
$$EXC = SC + (-PC) \quad \text{Eq. (3)}$$
$$TC = \sum (IC, EXC) \quad \text{Eq. (4)}$$

Table III Dataset after Data Cleaning

	DC/P	SC/P	PC/P	EC/P	AC/P	OC/P	IC/P	Q_Kilo
Products								
Beans_F_D	19.493261	23.255083	21.516531	22.741189	21.935531	21.516531	22.741189	13.287712
Beans_F_D	20.230227	21.931569	21.310080	20.416995	23.122183	21.516531	23.532076	13.287712
Beans_F_D	18.908299	23.391000	21.931569	22.738923	21.931569	21.639977	22.793127	13.287712
Cheese	19.135709	23.253497	22.253497	22.253497	20.931569	20.021067	21.546985	13.287712
Cheese	19.720672	22.516531	21.010178	21.890597	21.516531	19.760200	21.890597	13.287712
...	...	...	...	...	...	...	...	...
Tomatoes	17.700494	20.931569	19.931569	19.931569	19.931569	19.337561	20.664923	13.287712
Tomatoes	16.922886	22.253497	20.931569	21.516531	20.931569	20.209553	21.615265	13.287712
Wheat_flour	17.288434	21.931569	20.931569	20.931569	19.934451	19.931569	20.933011	13.287712
Wheat_flour	17.610362	20.931569	19.931569	19.931569	19.931569	18.935171	20.517733	13.287712
Wheat_flour	16.832754	21.516531	19.931569	20.931569	20.931569	20.808331	21.871265	13.287712

378 rows × 8 columns

Figure 7 Data correlation

- Stage 2: find the nearest optimum transportation cost using GA

In this stage, the nearest optimum solution for Transportation cost was detected using GA as shown in Algorithm1. Moreover, this stage was divided into three steps as follows:

Step1: Population Initialization

First, generate a population and define the number of Chromosomes ranging from "1 to 378" chromosomes using NumPy lib and refer to it as a set of {X}as shown in figure 8.

Then, split it into {X1 & X2} and encode each possible solvent as binary code "0s & 1s".

Step2: compute fitness function from the random binary chromosomes vector bits as shown in figure 9 as shown in Algorithm 1 step 2.

Table IV Data Description after Data cleaning

	count	mean	std	min	25%	50%	75%	max
DC/P	378.0	18.590326	1.604638e+00	15.284101	17.334727	18.457637	19.621998	23.111080
SC/P	378.0	22.611180	1.814080e+00	15.872675	21.516531	22.516531	24.215496	26.575425
PC/P	378.0	21.395715	2.011584e+00	13.609640	19.931569	21.131838	23.101494	26.253497
EC/P	378.0	21.655173	1.790959e+00	15.287712	19.931569	21.516531	22.908291	26.253497
AC/P	378.0	21.624528	1.557194e+00	17.960138	20.516531	21.516531	22.516531	25.838459
OC/P	378.0	20.984733	1.878147e+00	8.965784	19.931569	20.931569	22.253497	25.603994
IC/P	378.0	22.396648	1.589447e+00	18.795507	21.233518	22.288839	23.331379	26.611049
Q_Kilo	378.0	13.287712	2.490196e-14	13.287712	13.287712	13.287712	13.287712	13.287712

Table III Transportation Cost Calculation

Products	DC/P	SC/P	PC/P	EC/P	AC/P	OC/P	IC/P	Q_Kilo	TRC/P
Beans_F_D	19.493261	23.255083	21.516531	22.741189	21.935531	21.516531	22.741189	13.287712	23.741189
Beans_F_D	20.230227	21.931569	21.310080	20.416995	23.122183	21.516531	23.532076	13.287712	23.689659
Beans_F_D	18.908299	23.391000	21.931569	22.738923	21.931569	21.639977	22.793127	13.287712	23.766280
Cheese	19.135709	23.253497	22.253497	22.253497	20.931569	20.021067	21.546985	13.287712	22.943064
Cheese	19.720672	22.516531	21.010178	21.890597	21.516531	19.760200	21.890597	13.287712	22.890597
...	...	...	...	...	...	...	...	...	...
Tomatoes	17.700494	20.931569	19.931569	19.931569	19.931569	19.337561	20.664923	13.287712	21.344350
Tomatoes	16.922886	22.253497	20.931569	21.516531	20.931569	20.209553	21.615265	13.287712	22.566743
Wheat_flour	17.288434	21.931569	20.931569	20.931569	19.934451	19.931569	20.933011	13.287712	21.932290
Wheat_flour	17.610362	20.931569	19.931569	19.931569	19.931569	18.935171	20.517733	13.287712	21.254218
Wheat_flour	16.832754	21.516531	19.931569	20.931569	20.931569	20.808331	21.871265	13.287712	22.476610

378 rows × 9 columns

- Step3: Compute crossover and mutation.

For implementing this step, we select some chromosomes from one vector {X1} and some else from the other vector {X2} for making a crossover. To generate the children population by computing child fitness function as shown in Algorithm 1 step 2. After that, make a mutation and choose a random chromosome by changing its nature from 0s to 1s and vice versa.

Then, get the initial solvent population {P} where P= Population size and population size= 30. The fitness function retrieves the best solvent and obtains the minimum transportation cost in the population according to each iteration, where the number of iterations = 2000, as shown in figure 10.

Finally, figure 11 shows the behavior of the fitness function for all populations during its implementation.

```
[17 25 21 16 19 25 23 18 22 16 25 16 30 23 23 24 15 23 24 22 16 17 16 23
 15 22 22 28 24 27 19 30 27 27 26 27 23 26 24 29 25 22 19 18 15 22 21 23
 19 29 24 25 21 20 25 28 30 19 23 27 27 23 17 19 22 15 24 23 16 18 26 24
 23 20 27 18 23 30 22 24 17 30 20 24 22 25 25 22 28 15 22 29 24 15 29 27
 30 21 23 17 23 17 17 15 29 21 26 27 26 29 27 21 27 19 21 19 30 20 21 21
 21 25 24 21 15 23 25 17 29 28 24 29 28 22 18 15 17 19 29 17 25 26 19 29
 20 24 30 25 20 19 28 18 27 20 22 23 22 21 21 28 30 30 26 25 22 26 15 28
 21 30 28 27 29 15 18 29 26 27 28 30 29 21 27 30 22 27 24 28 26 20 28 26
 26 16 19 19 24 22 17 30 23 15 25 22 26 21 22 20 17 20 24 30 15 25 27 17
 30 16 21 19 23 21 19 21 24 30 18 25 30 22 17 18 21 26 27 18 30 26 19 18
 20 23 19 28 19 23 20 29 26 25 23 28 24 17 23 15 18 29 15 29 22 24 15 18
 28 27 24 24 24 23 19 23 21 28 16 18 27 15 28 25 19 18 15 19 23 24 16 20
 28 21 19 21 28 24 28 19 24 21 19 22 30 16 19 16 27 18 22 30 27 29 30 22
 21 29 30 24 20 30 21 23 27 21 17 19 20 26 18 18 20 15 16 16 28 17 23 28
 25 28 20 25 22 18 16 22 23 16 18 17 18 24 15 24 22 23 24 18 25 17 19 20
 24 15 25 15 21 28 29 16 30 29 29 16 26 18 28 16 17 23]
```

Figure 8 Generating sample of Transportation cost population

```
[0 0 0 1 1 0 1 1 0 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 1 1 1 0 0 1 1 0 1 0 1 0
 1 1 0 0 0 0 0 1 1 0 1 0 0 1 0 0 0 1 1 1 1 1 1 1 0 1 1 0 1 0 0 1 1 1 0 1 1
 1 0 1 0 1 1 1 0 0 0 1 0 1 0 0 0 0 1 1 0 1 1 0 1 1 1 0 0 0 0 1 1 0 1 1 1 0
 0 1 0 0 0 1 1 1 0 1 1 0 1 1 0 0 1 0 0 0 1 1 1 0 0 0 0 1 1 0 0 0 0 1 1 0 0
 1 1 1 0 1 1 0 1 0 1 1 0 1 0 0 0 0 1 0 1 1 1 1 1 0 0 1 1 0 0 1 1 1 0 0 1 0
 0 1 1 0 0 0 1 1 0 0 0 0 0 1 0 1 1 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 1 1
 0 0 0 1 1 1 1 1 0 0 1 0 1 0 1 1 1 0 1 1 0 1 1 1 1 1 1 0 1 0 0 1 0 0 1 0 0
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 0 1 0 0 1 0 0 1 1 1 0 1 1 1 0 0 1 0 0 0 1 1 0 0 1 0 0 1 0 1 1 0 1 0 1 0 1
 1 0 1 1 1 1 1 1 0 0 1 1 0 1 1 1 1 0 0 1 1 0 1 0 0 0 1 0 1 0 1 1 1 0 0 0 1
 1 1 1 1 1 0 0 0]
```

Figure 9 Array transformation to 0s and 1s after computing fitness function for parent chromosomes in Transportation Cost.

```
[1 1 1 0 0 0 0 0 1 0 0 1 1 0 1 0 0 0 1 1 0 1 0 1 1 1 1 1 0 0 1 0 0 0 1 1 0
 1 0 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 0 1 1 0 0 1 1 1 1 1 1 1 0 1 1 0
 1 1 1 0 1 0 0 0 1 1 0 0 1 1 1 0 0 1 1 1 1 1 0 0 0 0 1 1 0 1 1 1 1 0 1 0 1
 0 1 1 1 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 0 1 0 1 1 0 0 0 0 0 0 0 0 1 0
 1 1 1 1 0 1 1 0 1 1 1 0 1 0 1 0 0 1 0 1 1 0 1 1 0 1 0 0 1 0 1 1 1 0 1 1 0
 1 1 0 0 0 0 1 0 1 0 1 0 0 1 0 1 0 1 0 0 1 0 0 1 0 1 0 0 1 0 0 1 0 1 0 0 1
 0 0 1 1 1 0 0 1 1 0 0 1 1 0 1 1 0 1 1 0 0 0 1 0 0 0 0 1 1 0 0 0 1 1 1 1 1
 1 0 0 0 0 1 0 0 0 1 0 0 1 1 0 0 1 0 1 0 0 1 1 0 0 0 1 0 1 1 0 0 1 1 0 1 1
 0 0 0 1 0 0 0 1 0 0 0 1 1 0 0 1 1 0 0 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 1 0 0
 1 0 0 0 1 0 1 0 1 1 0 0 0 0 1 1 0 0 1 0 0 0 0 1 1 0 1 1 0 0 1 0 0 1 1 1
 0 0 1 1 1 0 1 0] 1
```

Figure 10 Array of minimum transportation cost after computing fitness function for children's chromosomes.

- Stage 3: compute the total cost for each Product and get the nearest optimum total cost using GA

The total cost for each Product was computed using the following equation as shown in Algorithm 1 and Table VI.

$$tc = \sum ((\text{AVG. FC}), (\text{Avg. VC})) \times Q \quad \text{Eq. (5)}$$

On the other hand, to get the nearest optimum total cost using GA, also, this stage was divided into three steps, the same as in the previous stage. so we will repeat the steps to get the nearest solvent which is the minimum total cost where the number of iterations =2000, as shown in figure 12, figure 13, and figure 14. Finally, figure 15 shows the behavior of the total cost fitness function for all populations during its implementation.

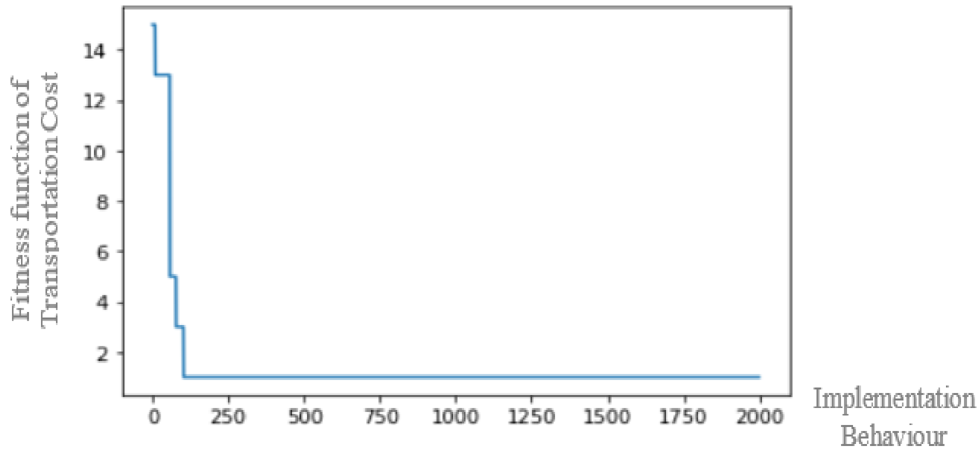

Figure 11 fitness function behavior for transportation cost population through implementation

Table VI Results of Total Cost Calculation for each Product

Products	FC/P	AVG_FC	VC/P	AVG_VC	DC/P	SC/P	PC/P	EC/P	AC/P	OC/P	IC/P	Q_Kilo	TRC/P	Total_Cost
Beans_F_D	23.230227	9.942515	23.815189	10.527477	19.493261	23.255083	21.516531	22.741189	21.935531	21.516531	22.741189	13.287712	23.741189	24.552155
Beans_F_D	23.230227	9.942515	23.815189	10.527477	20.230227	21.931569	21.310080	20.416995	23.122183	21.516531	23.532076	13.287712	23.689659	24.552155
Beans_F_D	23.230227	9.942515	23.815189	10.527477	18.908299	23.391000	21.931569	22.738923	21.931569	21.639977	22.793127	13.287712	23.766280	24.552155
Cheese	23.194603	9.906891	23.042600	9.754888	19.135709	23.253497	22.253497	22.253497	20.931569	20.021067	21.546985	13.287712	22.943064	24.120602
Cheese	23.194603	9.906891	23.042600	9.754888	19.720672	22.516531	21.010178	21.890597	21.516531	19.760200	21.890597	13.287712	22.890597	24.120602
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tomatoes	24.081316	10.793603	21.455381	8.167669	17.700494	20.931569	19.931569	19.931569	19.931569	19.337561	20.664923	13.287712	21.344350	24.297926
Tomatoes	24.566743	11.279030	22.595312	9.307599	16.922886	22.253497	20.931569	21.516531	20.931569	20.209553	21.615265	13.287712	22.566743	24.894430
Wheat_flour	24.254218	10.966505	21.988873	8.701161	17.288434	21.931569	20.931569	20.931569	19.934451	19.931569	20.933011	13.287712	21.932290	24.526838
Wheat_flour	23.991183	10.703471	21.365249	8.077537	17.610362	20.931569	19.931569	19.931569	19.931569	18.935171	20.517733	13.287712	21.254218	24.207793
Wheat_flour	24.476610	11.188898	22.505179	9.217467	16.832754	21.516531	19.931569	20.931569	20.931569	20.808331	21.871265	13.287712	22.476610	24.804298

378 rows × 14 columns

```
[22 30 30 28 26 23 25 26 28 30 28 28 23 23 25 20 27 25 28 27 20 27 23 29
 26 28 20 30 24 27 29 26 24 22 26 27 27 20 24 26 26 30 30 28 26 28 27 20
 28 21 21 29 22 26 20 24 29 23 20 27 26 30 26 28 20 26 25 26 27 22 26 23
 24 29 30 28 23 21 22 29 24 23 27 20 30 28 28 21 28 28 24 23 30 25 23 21
 21 23 25 23 28 21 28 30 22 24 27 29 28 28 25 21 24 23 20 23 24 25 23 24
 30 30 21 28 24 26 27 28 30 24 28 24 29 27 26 20 27 23 23 23 28 25 28 24
 26 26 20 28 25 24 26 27 29 22 27 27 22 21 22 23 26 24 29 21 28 24 24 28
 22 26 30 20 27 27 20 21 25 21 29 20 21 23 21 25 20 24 27 24 22 21 20 27
 24 24 26 25 25 29 23 24 25 26 22 23 21 30 25 25 21 27 21 21 24 22 22 20
 22 20 22 26 29 25 23 23 23 22 29 29 20 26 23 26 24 28 29 26 21 24 24 20
 29 21 30 22 28 20 25 24 28 23 26 21 27 20 26 21 26 23 23 21 25 26 26 25
 29 22 20 27 25 24 23 27 30 24 22 25 21 30 25 20 23 30 24 24 28 20 30 26
 21 29 30 27 23 23 23 25 28 25 22 24 30 21 22 21 30 28 28 26 26 29 23 23
 25 29 24 22 21 27 25 20 23 29 25 26 25 28 27 27 20 20 21 28 26 29 20 29
 22 22 30 20 27 23 21 30 23 22 21 23 24 28 22 20 28 23 25 23 28 26 27 28
 23 27 24 21 24 28 21 29 24 30 30 28 23 25 24 27 21 26]
```

Figure 12 Generating Sample of Total cost population.

- Stage 4: Calculating profit for each predicted Product

After predicting the nearest optimum total cost, we will compute the total revenue for each predicted Product; After that, we compute the profit for each predicted by the following equations as shown in Algorithm 1 “step 4”.

$$TR = P \times Q \qquad \text{Eq. (6)}$$
$$PR = \sum(TR(-tc)) \quad \text{Eq. (7)}$$

Also, the following table VII will show the results of these equations. Finally, calculate the correlation for the final dataset and get the description for it before transforming data into bins to find the boundary profit, as shown in figure 16 and table VIII.

```
[0 0 1 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 1 1 1 1 1 1 1 1 1 1 0 0 1 0 0 0 1 0 0
 0 1 1 1 0 0 0 0 0 0 1 0 1 1 0 0 1 1 0 0 1 0 1 0 1 0 0 0 1 1 1 1 1 1 0 0 0
 0 0 0 0 1 0 0 1 0 0 0 0 0 0 1 1 1 1 0 0 0 1 1 1 1 1 1 0 0 1 0 0 0 1 0 0 0
 1 0 0 0 1 1 1 0 1 1 1 0 0 1 1 1 1 0 1 1 1 0 1 1 0 0 1 0 1 1 0 1 0 1 0 1 0
 1 0 1 0 0 0 1 0 0 0 0 0 1 0 1 0 0 1 0 1 1 0 0 1 0 0 0 1 1 0 1 0 1 0 1 0 1
 1 0 1 1 1 0 1 0 1 0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 1 0 0 1 0 0 0 0 1 1 1 1 1
 0 0 1 1 1 0 1 0 0 1 0 0 1 0 0 0 1 0 1 0 0 0 1 0 1 0 1 0 0 1 0 0 0 0 0 0 0
 0 0 1 1 0 0 1 0 0 1 1 0 1 1 0 1 0 1 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0
 1 0 0 0 0 0 0 0 1 0 0 0 1 1 1 1 1 1 0 1 0 0 0 1 1 0 1 0 1 0 1 1 0 0 0 0 0
 0 0 1 1 0 1 0 1 1 0 1 0 1 1 0 1 1 0 0 0 1 0 1 1 0 0 1 1 0 1 1 1 1 0 1 0 0
 0 0 1 0 1 1 1 1]
```

Figure 13 Array transformation to 0s and 1s after computing fitness function for parent chromosomes in total cost.

```
[1 0 1 0 0 1 1 0 1 0 0 0 0 1 1 0 0 0 0 1 0 0 0 0 1 0 1 1 1 0 1 0 1 0 0 0 1
 0 0 1 1 0 0 0 0 1 1 0 0 1 1 1 0 1 1 0 0 0 0 0 1 0 0 1 1 0 0 1 0 1 1 1 1 0
 0 0 0 0 1 1 1 1 1 1 1 0 1 0 1 1 0 1 1 0 0 0 0 1 0 1 0 0 1 1 0 0 0 0 1 1 1
 1 0 1 0 0 0 1 1 1 0 0 1 1 1 1 0 0 0 1 1 0 0 0 1 0 0 1 1 0 0 1 1 0 1 1 1 0
 1 0 1 1 0 1 1 0 0 1 0 0 0 1 0 0 1 1 0 0 0 0 1 1 0 0 0 1 0 1 1 0 1 0 0 0 1
 0 1 0 0 1 1 1 0 0 1 0 1 1 1 1 1 1 1 0 0 1 0 1 1 0 1 0 0 1 0 0 1 0 0 0 1 1
 1 1 1 1 1 1 1 0 0 1 0 0 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 0 0 1 0 0 1 0 0 0
 0 0 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0 1 0 1 1 0 1 1 1 0 0 1 1 1 0 1 0 0 0 1 0
 1 1 1 0 0 0 0 1 1 1 0 1 0 1 1 1 1 1 0 1 1 1 1 1 0 1 0 0 0 0 0 1 0 1 0 0 0
 1 0 1 0 0 1 1 0 0 0 1 0 0 1 0 0 0 1 0 1 1 0 0 1 0 0 1 1 0 0 1 1 1 1 0 0 1
 0 1 1 1 1 1 1 1] 1
```

Figure 14 Array of the minimum total cost after computing fitness function for children's chromosomes.

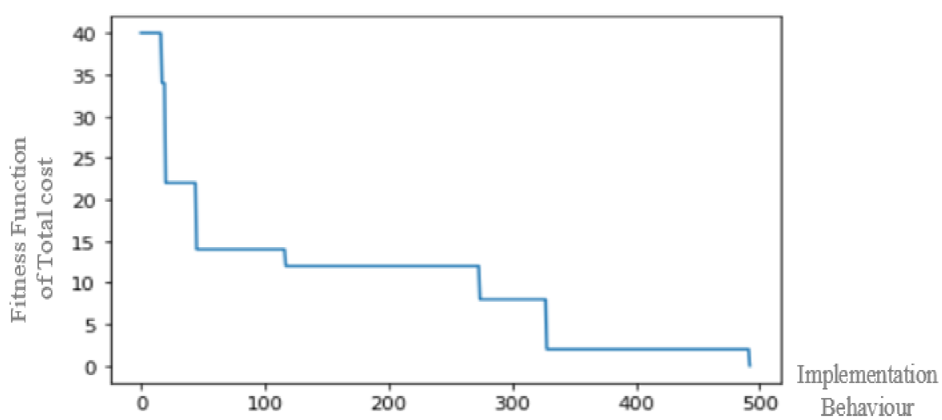

Figure 15 fitness function behavior for total cost population through implementation.

- Stage 5 Computing boundary profit

Using SKFUZZY lib, take the value of the profit retrieved from detecting the optimum value of profit for products; after that, transform these values into bins to get the range of profit as shown in figure 17. On this hand, using triangular fuzzy logic detect that the minimum profit will involve between (20 billion and 23.9 billion), while moderate profit is detected as (24 billion), and the maximum profit will be more than (24.1 billion).

- Stage 6 uses the Pandas Matplotlib tool for data visualization after detecting all results derived from FGA Algorithm, as shown in figure 18.

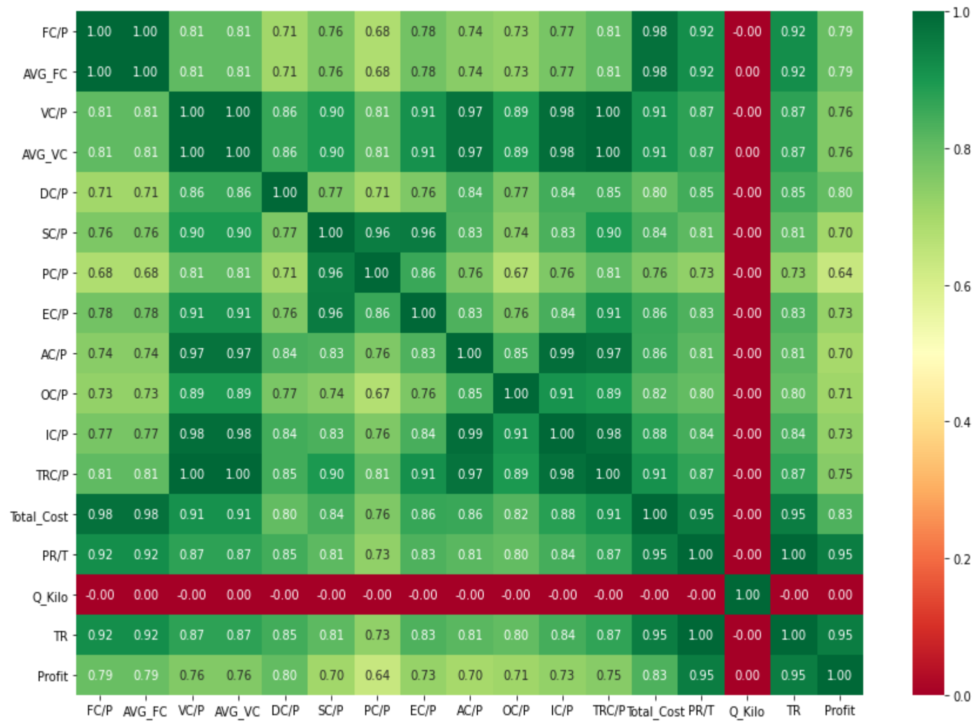

Figure 16 Whole Dataset Correlation.

Table VII final dataset description

	count	mean	std	min	25%	50%	75%	max
FC/P	378.0	25.049340	1.619749e+00	21.627562	23.838459	24.984438	26.043133	28.948377
AVG_FC	378.0	11.761628	1.619749e+00	8.339850	10.550747	11.696725	12.755421	15.660664
VC/P	378.0	23.207575	1.585718e+00	19.816596	22.065143	23.059056	24.169816	27.471890
AVG_VC	378.0	9.919863	1.585718e+00	6.528884	8.777430	9.771344	10.882104	14.184178
DC/P	378.0	18.590326	1.604638e+00	15.284101	17.334727	18.457637	19.621998	23.111080
SC/P	378.0	22.611180	1.814080e+00	15.872675	21.516531	22.516531	24.215496	26.575425
PC/P	378.0	21.395715	2.011584e+00	13.609640	19.931569	21.131838	23.101494	26.253497
EC/P	378.0	21.655173	1.790959e+00	15.287712	19.931569	21.516531	22.908291	26.253497
AC/P	378.0	21.624528	1.557194e+00	17.960138	20.516531	21.516531	22.516531	25.838459
OC/P	378.0	20.984733	1.878147e+00	8.965784	19.931569	20.931569	22.253497	25.603994
IC/P	378.0	22.396648	1.589447e+00	18.795507	21.233518	22.288839	23.331379	26.611049
TRC/P	378.0	23.136173	1.595518e+00	19.705565	21.986851	23.001958	24.101494	27.443321
Total_Cost	378.0	25.473232	1.526285e+00	22.659141	24.255933	25.281167	26.366521	29.276064
PR/T	378.0	13.465814	1.502015e+00	10.965784	12.228819	13.358102	14.340824	17.175238
Q_Kilo	378.0	13.287712	2.490196e-14	13.287712	13.287712	13.287712	13.287712	13.287712
TR	378.0	26.753526	1.502015e+00	24.253497	25.516531	26.645814	27.628536	30.462950
Profit	378.0	25.866366	1.623108e+00	22.236080	24.675765	25.734095	26.971174	29.967825

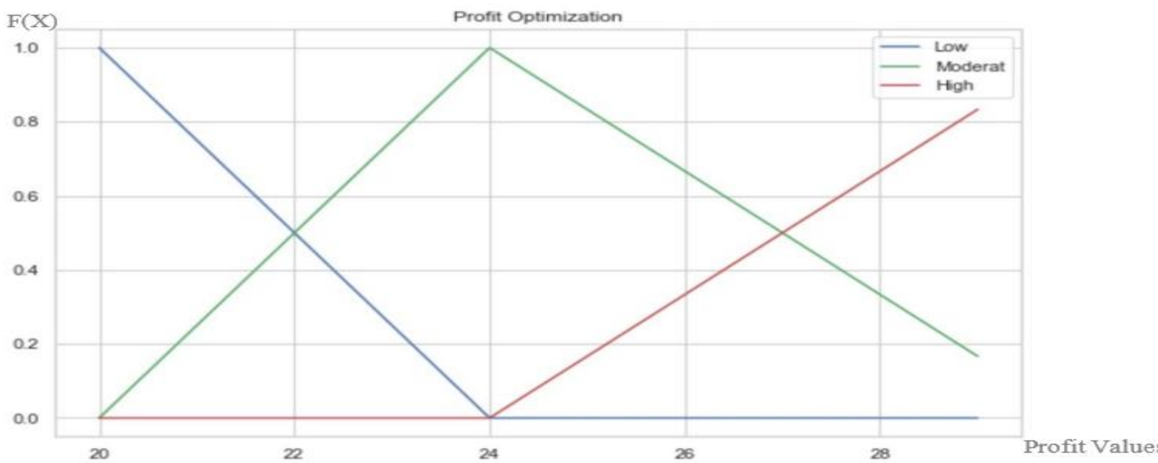

Figure 17 boundary profit using triangular fuzzy logic.

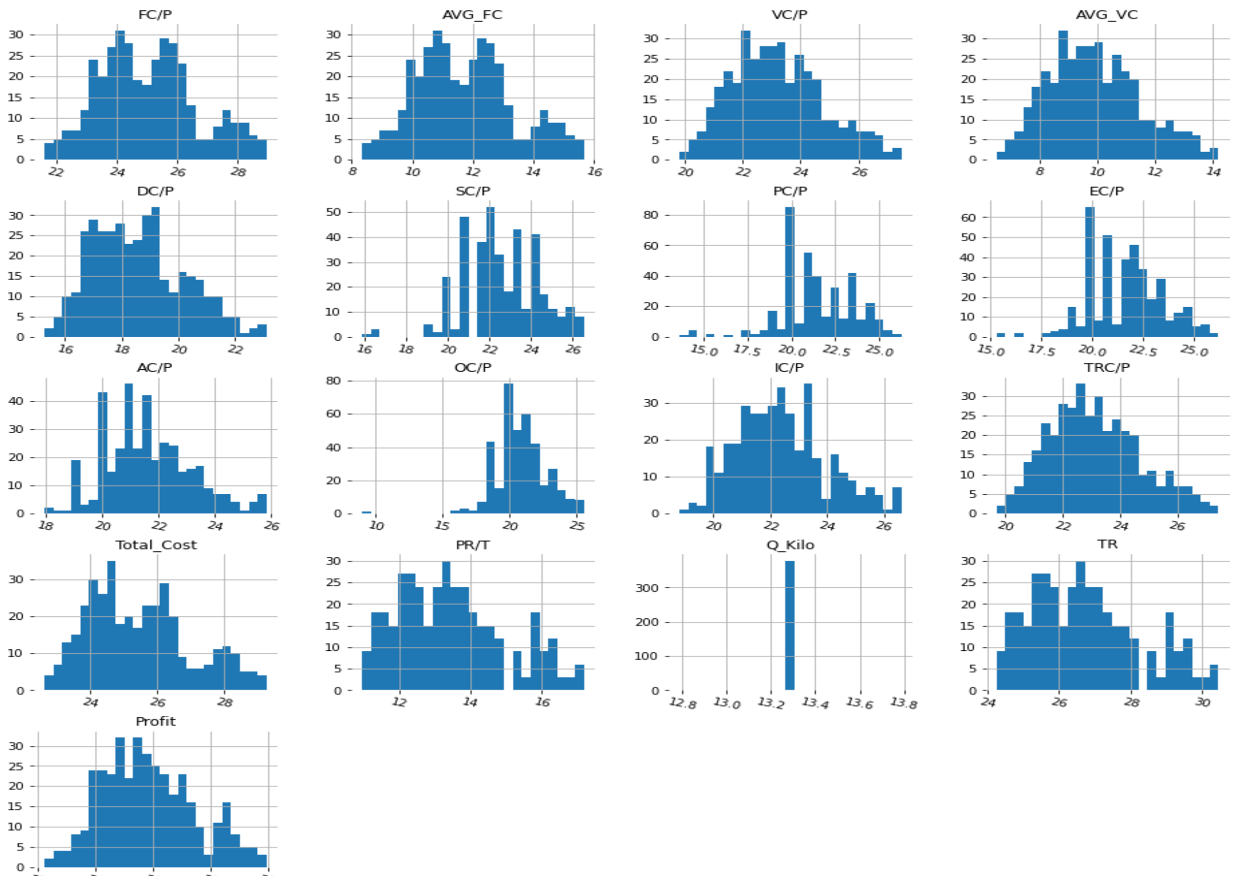

Figure 18 Data visualization using the Matplotlib tool

Table VII Results of calculating total revenue and profit.

Products	FC/P	AVG_FC	VC/P	AVG_VC	DC/P	SC/P	PC/P	EC/P	AC/P	OC/P	IC/P	TRC/P	Total_Cost	PR/T	Q_Kilo	TR	Profit
Beans_F_D	23.230227	9.942515	23.815189	10.527477	19.493261	23.255083	21.516531	22.741189	21.935531	21.516531	22.741189	23.741189	24.552155	13.001408	13.287712	26.289121	25.774547
Beans_F_D	23.230227	9.942515	23.815189	10.527477	20.230227	21.931569	21.310080	20.416995	23.122183	21.516531	23.532076	23.689659	24.552155	13.001408	13.287712	26.289121	25.774547
Beans_F_D	23.230227	9.942515	23.815189	10.527477	18.908299	23.391000	21.931569	22.738923	21.931569	21.639977	22.793127	23.766280	24.552155	13.001408	13.287712	26.289121	25.774547
Cheese	23.194603	9.906891	23.042600	9.754888	19.135709	23.253497	22.253497	22.253497	20.931569	20.021067	21.546985	22.943064	24.120602	12.965784	13.287712	26.253497	25.880169
Cheese	23.194603	9.906891	23.042600	9.754888	19.720672	22.516531	21.010178	21.890597	21.516531	19.760200	21.890597	22.890597	24.120602	12.965784	13.287712	26.253497	25.880169
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tomatoes	24.081316	10.793603	21.455381	8.167669	17.700494	20.931569	19.931569	19.931569	19.931569	19.337561	20.664923	21.344350	24.297926	12.793603	13.287712	26.081316	25.586190
Tomatoes	24.566743	11.279030	22.595312	9.307599	16.922886	22.253497	20.931569	21.516531	20.931569	20.209553	21.615265	22.566743	24.894430	12.793603	13.287712	26.081316	25.246745
Wheat_flour	24.254218	10.966505	21.988873	8.701161	17.288434	21.931569	20.931569	20.931569	19.934451	19.931569	20.933011	21.932290	24.526838	12.703471	13.287712	25.991183	25.341907
Wheat_flour	23.991183	10.703471	21.365249	8.077537	17.610362	20.931569	19.931569	19.931569	19.931569	18.935171	20.517733	21.254218	24.207793	12.703471	13.287712	25.991183	25.496058
Wheat_flour	24.476610	11.188898	22.505179	9.217467	16.832754	21.516531	19.931569	20.931569	20.931569	20.808331	21.871265	22.476610	24.804298	12.703471	13.287712	25.991183	25.156613

378 rows × 17 columns

7. Conclusions and Recommendations

AI has become the most powerful technique in business since it is embroiled in many fields specified in business logistics. AI entered and became an integral part of logistics, especially in transportation logistics, to solve complex and multimodal problems.

The main objective of this paper, as discussed previously, is "how to obtain optimization between any organization's profits and customer satisfaction using AI techniques?".

Our main contribution to this paper was made by making a proposed Transportation Logistics model and FGA algorithm for obtaining both organization and customer satisfaction.

A dataset was collected from the "Egyptian Portal for Transportation" from 2014 to 2020.

Dataset was divided into three main categories, "landline, marine line, and airline". Results that were derived from using GA show that minimizing the transportation cost took a "2000" number of iterations. Also, it took the "2000" number of iterations to minimize total cost and took the best of 5: 1.53 MS (millisecond)/ loop of time for minimizing transportation cost and the best of 5: 1.40 MS/ loop for minimizing total cost.

In this way, minimizing transportation costs and the total cost of each Product will affect customer satisfaction for purchasing products at a possible price.

After that, the total profit was identified and transformed into estimated values by dividing them into bins using triangular fuzzy logic "SKFUZZY tool" to generate the ranges of profit that derived the target, which is optimizing total profit for products in the organizations. According to that, organizations will reach their goals. The results show that the minimum profit will be involved between (20 billion and 23.9 billion), while moderate profit is detected as (24 billion), and the maximum profit is more than (24.1 billion).

So, in this research paper, we can advise organizations to use the proposed FGA Algorithm and the proposed model for facilitating the prediction of redistribution of producing the products based on its time. Moreover, it will enable organizations to predict how to insert a new line of products based on the profit that will be detected. It will also facilitate how to detect the demand and the supply for each Product.

Finally, we can recommend and announce the future work of this paper, which will be a new area in AI methods that involves three AI techniques together to solve multimodal and hardest issues, which are the Neuro-Fuzzy-Genetic Algorithm "NFGA" that can be integrated for solving the hardest and most complex problems.

Data Availability: The described data referred to in this paper are available in the open-access portal in Egypt. [Transport Services (cairo.gov.eg)]

Funding: This research received no external funding.

Conflicts of Interest: Declare conflicts of interest or state, "The authors declare no conflict of interest."

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Notation:

BI	**Business Intelligence**
BIS	**Business Information System**
FGA	**Fuzzy Genetic Algorithm**
DC/P	**Depreciation Cost per Product**
SC/P	**Social Cost per Product**
PC/P:	**Private Cost per Product**
EC/P	**External Cost per Product**
AC/P	**Accounting Cost per Product**
OC/P	**Opportunity Cost per Product**
IC/ P	**Internal Cost per Product**
Q_Kilo	**Quantity of Products measured by Kilo**
TRC/P	**Transportation Cost per Product**
FC/P	**Fixed Cost per Product**
AVG_FC	**Average of Fixed Cost**
VC/P	**Variable Cost per Product**
AVG_VC	**Average of Variable Cost**
PR	**Price per Tones**
TR	**Total Revenue**