



## A HYBRID APPROACH OF GENETIC ALGORITHMS AND SIMULATION FOR OPTIMIZING SUPPLY CHAIN DECISIONS

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### Abstract

This study is dedicated to developing a hybrid approach that integrates genetic algorithms with simulation to optimize decision-making processes within supply chains. In the increasingly complex landscape of modern supply chains, there is a pressing need for efficient methods to tackle the challenges associated with decision-making. Genetic algorithms have demonstrated their efficacy in identifying optimal solutions, while simulation offers valuable insights into the dynamics of existing systems. The methodology employed in this research involves the application of genetic algorithms to seek out the best solutions based on predefined input parameters. These solutions are then validated through simulation, aiming to evaluate the system's performance under a variety of potential scenarios. The findings of the study reveal that the synergy between genetic algorithms and simulation significantly enhances the efficiency of supply chain decision-making, achieving cost reductions and improvements in customer service. Consequently, the conclusion drawn from this research is that the hybrid approach is effective in optimizing supply chain decisions, providing solutions that are more adaptive and responsive to market fluctuations. Therefore, it is recommended that companies adopt this approach to boost competitiveness and responsiveness in their supply chain operations.

**Keywords:** genetic algorithms, simulation, supply chain decision-making, cost reduction, hybrid approach

### INTRODUCTION

In the era of globalization and intense market competition, efficiency and effectiveness in supply chain management are paramount for companies to survive and thrive. This research is significant as it proposes an innovative solution to optimize supply chain decisions, potentially leading to cost reductions and enhanced customer service. Traditional approaches often fall short in addressing the complexities and dynamics of today's market, necessitating more sophisticated and flexible methods.

Previous studies have shown that genetic algorithms can be effective in finding optimal solutions for various complex problems, including those in supply chain contexts. For instance, Zhu et al. (2008) developed an integrated contract strategy in a three-echelon supply chain with capacity limitations based on demand forecasts. Additionally, Hua and Junhu (2008) proposed an optimization model for a multi-echelon stochastic inventory system in the supply chain.

However, genetic algorithms alone may not fully capture the consequences of the decisions made due to their lack of capability to model and simulate the actual interactions within a system. Therefore, the integration of genetic algorithms with simulation represents the next logical step in the evolution of supply chain optimization methods.

The aim of this research is to develop and test a hybrid approach that combines the strengths of genetic algorithms and simulation. With this approach, a deeper understanding of how certain decisions can impact the overall performance of the supply chain in different scenarios is anticipated. The expected outcome is to provide more accurate and reliable guidance for decision-making in supply chain management practices.

### **Problem Statement**

1. How can genetic algorithms be integrated with simulation to enhance decision-making efficiency in supply chain management?
2. Can a hybrid approach be combining genetic algorithms and simulation yield more optimal solutions than using genetic algorithms or simulation separately in the context of supply chains?
3. How can this hybrid approach assist in reducing operational costs and improving customer satisfaction in supply chain management?
4. What challenges might be encountered in implementing this hybrid approach and how can they be addressed?

### **Research Objectives**

1. To develop a hybrid approach that integrates genetic algorithms with simulation for optimizing decision-making in supply chain management.
2. To evaluate the effectiveness of the hybrid approach in producing more optimal solutions for supply chain management compared to conventional methods.
3. To analyze the impact of using the hybrid approach on reducing operational costs and enhancing customer satisfaction.
4. To identify and overcome challenges that arise in the implementation of the hybrid approach in supply chain management.

### **Theoretical Framework**

#### **a. Genetic Algorithms**

Genetic Algorithms (GAs) are search and optimization methods inspired by the process of natural selection. Introduced by Holland (1975), these algorithms utilize evolutionary mechanisms such as selection, crossover, and mutation to find optimal solutions within a large search space. In the context of supply chain management, genetic algorithms are effective in addressing complex problems such as scheduling, inventory management, and distribution network design (Zhang et al., 2015).

#### **b. Simulation**

Simulation is a technique that allows businesses to model and analyze their supply chain systems in a virtual environment. Through simulation, companies can test various operational scenarios without the risks associated with real-world operations. According to Law and Kelton (2000), simulation aids in understanding system dynamics and the impact of various decisions made.

#### **c. Hybrid Approach**

The hybrid approach that combines genetic algorithms with simulation offers great potential for enhancing decision-making in supply chains. By integrating these two methods, companies can leverage the strengths of each,

where genetic algorithms provide optimal solutions and simulation offers insights into dynamic interactions within the system. Wang et al. (2019) suggest that this approach can improve both efficiency and effectiveness in decision-making.

d. Related Research

A number of studies have explored the application of this hybrid approach in the supply chain context. For instance, Jha et al. (2020) demonstrated that the combination of GA and simulation can significantly enhance supply chain performance. Another study by Tzeng et al. (2015) suggested that merging genetic algorithms with simulation can help identify better solutions in complex and uncertain contexts.

## METHODS

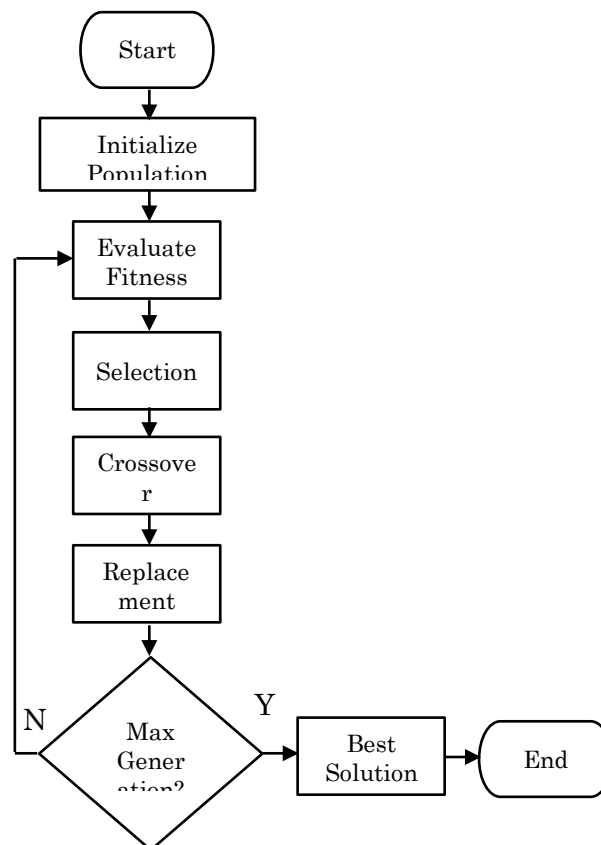


Figure 1.  
Flowchart hybrid genetic algorithm and simulation approach

The flowchart above outlines the steps involved in the hybrid genetic algorithm and simulation approach. Here's a detailed explanation of each component:

- a. Start. This marks the beginning of the hybrid algorithm process
- b. Initialize Population. In this step, an initial set of random solutions (also known as chromosomes) is generated. This forms the starting point for the algorithm.
- c. Evaluate Fitness. Each solution in the population is evaluated based on a fitness function. The fitness function could be the total cost associated with the solution, which needs to be minimized.

$$Total\ Cost = \sum_{i=1}^m (C_{ti} + C_p) \times Q_i$$

Where:

- $C_{ti}$  = Transportation cost from the distribution center to the i-th customer
- $C_p$  = Production cost per unit
- $Q_i$  = Order quantity of the i-th customer
- $m$  = Number of customers

- d. Selection. After evaluating the fitness of each solution, the best-performing solutions are selected. This selection is typically based on the fitness scores, where solutions with lower costs have a higher chance of being chosen for the next steps.
- e. Crossover. Selected solutions (parents) are combined to create new offspring solutions. This process is aimed at mixing the genetic material of the parents to produce potentially better solutions.
- f. Mutation. Random changes are introduced to the offspring solutions to maintain genetic diversity within the population. This helps prevent premature convergence to suboptimal solutions.
- g. Replacement. The population is updated by replacing the old solutions with the newly created offspring. This is crucial for evolving the population over generations.
- h. Termination Condition? At this point, the algorithm checks whether a termination condition has been met. This could be reaching a predefined maximum number of generations or finding a solution that meets a satisfactory criterion.
  - 1) **Yes**, If the termination condition is met, the algorithm proceeds to the next step.
  - 2) **No**, If the termination condition is not met, the process loops back to the "Evaluate Fitness" step to continue the iterations.
- i. Output Best Solution. Once the algorithm has terminated, it outputs the best solution found during the iterations. This solution is considered the optimal or satisfactory outcome based on the defined criteria.
- j. End. This marks the conclusion of the hybrid genetic algorithm and simulation process.

## RESULT AND DISCUSSION

This research was conducted by observing the supply chain of XYZ Company, which operates in the snack food industry in Bandar Lampung, over a one-week period. The company has four distribution centers used to serve customers in the southern regions of Java and Sumatra. The sample data consists of 10 customer data points located across Java and Sumatra, with the assumption that the data has been adjusted by applying a percentage adjustment from the actual data. The following table presents customer demand, distribution costs, and production costs:

Table 1.  
Data of customer demand, distribution costs, and production costs

| Customer    | Location       | Order Quantity (units) | Transport Cost from Bandar Lampung (IDR/unit) | Transport Cost from Jakarta (IDR/unit) | Transport Cost from Semarang (IDR/unit) | Transport Cost from Jambi (IDR/unit) | Production Cost (IDR/unit) |
|-------------|----------------|------------------------|---|--|---|--------------------------------------|----------------------------|
| Customer 1  | Palembang      | 200                    | 5.000   | 6.000                                  | 7.000                                   | 8.000                                | 15.000                     |
| Customer 2  | Bengkulu       | 150                    | 6.000   | 7.000                                  | 8.000                                   | 9.000                                | 15.000                     |
| Customer 3  | Bandar Lampung | 300                    | 2.000   | 5.000                                  | 6.000                                   | 7.000                                | 15.000                     |
| Customer 4  | Jambi          | 100                    | 7.000   | 8.000                                  | 6.500                                   | 2.000                                | 15.000                     |
| Customer 5  | Serang         | 180                    | 5.500   | 4.000                                  | 5.000                                   | 6.500                                | 15.000                     |
| Customer 6  | Jakarta        | 250                    | 6.000   | 2.000                                  | 4.500                                   | 8.000                                | 15.000                     |
| Customer 7  | Bandung        | 220                    | 6.500   | 3.000                                  | 5.500                                   | 8.500                                | 15.000                     |
| Customer 8  | Semarang       | 170                    | 6.000   | 5.500                                  | 2.000                                   | 6.000                                | 15.000                     |
| Customer 9  | Yogyakarta     | 130                    | 6.000   | 5.000                                  | 3.000                                   | 7.000                                | 15.000                     |
| Customer 10 | Solo           | 190                    | 6.500   | 5.500                                  | 3.500                                   | 7.500                                | 15.000                     |

Based on the data above, several chromosomes or alternative solutions are created from the distribution center to the customers.

Table 2.  
Chromosomes Initialization

| Customer    | Chromosome 1 | Chromosome 2 | Chromosome 3 | Chromosome 4 | Chromosome 5 |
|-------------|--------------|--------------|--------------|--------------|--------------|
| Customer 1  | 0            | 2            | 1            | 3            | 0            |
| Customer 2  | 1            | 0            | 2            | 3            | 1            |
| Customer 3  | 0            | 0            | 0            | 0            | 0            |
| Customer 4  | 3            | 3            | 3            | 0            | 2            |
| Customer 5  | 1            | 2            | 0            | 1            | 1            |
| Customer 6  | 1            | 1            | 1            | 2            | 0            |
| Customer 7  | 1            | 1            | 0            | 1            | 3            |
| Customer 8  | 2            | 2            | 2            | 1            | 1            |
| Customer 9  | 2            | 2            | 2            | 2            | 1            |
| Customer 10 | 2            | 1            | 2            | 0            | 3            |

0 = Bandar Lampung    1 = Jakarta                      2 = Semarang                      3 = Jambi

By using the fitness function, the best chromosome with the lowest total cost is obtained as follows:

Table 3.  
Fitness Result for Chromosomes

| No | Chromosomes   | Fitness (Total Cost) |
|----|---------------|----------------------|
| 1  | Chromosomes 1 | 34.475.000           |
| 2  | Chromosomes 2 | 35.285.000           |
| 3  | Chromosomes 3 | 35.865.000           |
| 4  | Chromosomes 4 | 37.665.000           |
| 5  | Chromosomes 5 | 38.750.000           |

After identifying the best chromosome, the next step is to perform mutation and crossover on the two best chromosomes to generate new combinations. The result of the chromosome combination will produce a new

mutated chromosome. The crossover and mutation iterations should be performed continuously until the most optimal solution is found.

## CONCLUSION

After performing crossover and mutation up to the 25th iteration on several chromosome alternatives above, the best fitness was obtained with a total cost of 34,725,000, with the following distribution center combinations:

Table 4.  
Best chromosome

| Customer    | Distribution Center |
|-------------|---------------------|
| Customer 1  | 2                   |
| Customer 2  | 0                   |
| Customer 3  | 0                   |
| Customer 4  | 3                   |
| Customer 5  | 1                   |
| Customer 6  | 1                   |
| Customer 7  | 1                   |
| Customer 8  | 2                   |
| Customer 9  | 2                   |
| Customer 10 | 2                   |

The data above is the result of the 25th iteration; further iteration processes can provide a greater opportunity to find a more optimal solution in reducing total distribution costs. With more iterations, the genetic algorithm will have more chances to explore various combinations of distribution centers and make improvements through selection, crossover, and mutation.

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