

E-Shopping Supply Chain Management using Genetic Algorithm and Fuzzy Approach

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ABSTRACT: In today's global marketplace, globalization policies and upgrading have created a more intensive competition amongst manufacturers. The competitive environment of global markets has forced many manufacturers to set up the most appropriate management for reduction of total costs and wasted time of supply chain. The aim of this paper is propose a model for just in time distribution in the e-shopping business under supply chain management. The objectives of the proposed model are to minimize the costs of the distribution, holding and minimizing the sum of backorders and supply of defective products in all periods. In this paper, we introduced genetic algorithm and fuzzy approach for minimize cost at various stages of supply chain. Genetic algorithm is a powerful technique to solve multi objective function problems. Fuzzy sets permits the values in Genetic algorithm expressed in range value with membership function embedded on it. Fuzzy logic can be used to select the most presented solution or final solution.

KEYWORDS: Supply Chain Management, e-shopping, Genetic Algorithm and Fuzzy Approach.

I. INTRODUCTION

Online shopping or e-shopping is a form of electronic commerce which allows consumers to directly buy goods or services from a seller over the Internet using a web browser. Alternative names are: e-web-store, e-shop, e-store, Internet shop, web-shop, web-store, online store, online storefront and virtual store. Mobile commerce (or m-commerce) describes purchasing from an online retailer's mobile optimized online site or app.

In the e-shopping business supply chain management (SCM) assumes a significant importance and calls for serious research attention, as companies are challenged with finding ways to meet ever-rising customer expectations at a manageable cost. To do so, businesses must search out which parts of their supply-chain process are not competitive, understand which customer needs are not being meet, establish improvement goals and rapidly implement necessary improvements. Today, customers are conscious about products and manufacturers move quickly to meet customer demands, quick order fulfilment and fast delivery. So, meeting customer's specific demands for product delivery has emerged as the next critical opportunity for competitive advantage.

The aim of this paper is to propose a model for just-in-time (JIT) distribution in the e-shopping business under the SCM. The objectives of the proposed model are to minimize the costs of the distribution, holding and minimizing the sum of backorders and supply of defective products in all periods. In this model there are two objective functions, three level supply chain consisting of manufactures, e-shopping agencies, customers and delivery lead time. Capacity constraints are also considered in multi-period, multi- product and multi channel system. The concept of JIT delivery is generally incorporated into models by means of earliness and tardiness costs, but here it is defined as a new objective function which is in conflict with the cost minimization. JIT delivery plays an important role in efficient distribution of goods. When customer places replenishment orders on products, cost and delivery are the two key factors. Inventory control and distribution planning, as fundamental logistical processes, affect the total costs of the supply chain to a great extent, but, on the other hand, have a great effect on the customers' service level.

In this paper for solving multi-objective large-size problem we introduced the genetic algorithm (GA) and fuzzy approach. GA which are search heuristics that mimic the process of natural evolution, have been routinely used to generate useful solutions for optimization and search problems. Fuzzy sets permits the values in Genetic algorithm expressed in range value with membership function embedded on it. Fuzzy logic can be used to select the most presented solution or final solution.

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There are similar studies applied by past scientists in SCM. Reza Z. Farahani et al. (2008) [11] developed and solved a new model for just in time distribution in the context of supply – chain management. A bi- objective model was set up for the distribution network of a three – echelon supply chain, with the objectives of minimizing costs and minimizing the sum of backorders and surplus of products in all periods. They preferred the lower costs to the higher service levels or vice versa, while on other occasions, ignored costs for the customers satisfaction purposes. A coding system was also proposed to classify the work done in the field distribution networks in the context of supply chain management.

Aliev R.A. et al. (2007) [10] considered the fuzzy integrated multi-period multi-product production–distribution aggregate planning (PDAP) model in SC in which customer demand and capacities in production environment are uncertain. The model is formulated in terms of fuzzy programming and the solution is provided by genetic algorithm. The suggested integrated production–distribution planning model is based on a fuzzy mathematical programming problem with fuzzy objective function, soft constraints and fuzzy decision variables solved by genetic algorithm that provides a general near-optimal plan. Their results showed that high efficiency of the proposed method. Seyed Hamid, R. Pasandideh et al. (2011) [14] were developed an economic order quantity (EOQ) model for a two –level supply chain system consisting of several products, one supplier and one retailer, in which shortages are backordered, the supplier's warehouse has limited capacity and there was an upper bound on the number of orders. The model was taken as non-linear integer programming type, a genetic algorithm was proposed to find out the order quantities and maximum backorder levels such as the total inventory cost of the supply chain was minimized. Finally, with help of one example demonstrated the applicability of the proposed methodology and to evaluate the fitness function of the genetic algorithm.

Salah Alden Ghasimi et al. (2014) [13] proposed genetic algorithms (GAs) for optimizing a novel mathematical model of the defective goods supply chain network (DGSCN). The objective was to minimize the costs of production, distribution, holding and backorder. In their model, determined the economic production quantity (EPQ), the appropriate length of each cycle (ALOC) and the quantities of defective products, scrap products and retailer shortages by using Just – In- Time Logistics (JIT-L). They have used Gas and Cplex solver with probability parameters and various dimensions for validation of the studied model in real life situations and compared the outputs to demonstrate the performance of model. Additionally, identified the appropriate length of each cycle (ALOEC). Neslihan Demirel et al. (2014) [9] proposed a mixed integer programming model for a closed-loop supply chain (CLSC) network with multi periods and multi-parts under two main policies as secondary market pricing and incremental incentive policies. For the base case (crisp) formulation, a fuzzy multi-objective extension is applied to solve CLSC network problem with fuzzy objectives to represent vagueness in real-world problems. And, genetic algorithm approach is applied to solve real size crisp and fuzzy CLSC problems.

The organization of this paper is as follows: Description of the problem is given in Section 2 and Section 3 presents the mathematical formulation of the three-stage SC distribution problem. In Section 4, the proposed Genetic algorithm and methodology to optimize solution is explained. Finally, conclusions are given in Section 5.

II. DEFINE THE PROBLEM

Consider an e-shopping business consisting of n products, multi suppliers and multi option of e-shopping sites.

We propose a mathematical model for a JIT in e-shopping business to minimize the costs of distribution, holding, replacement and backorder. The proposed model deals with the distribution decisions of a three – level- supply chain. At level first multiple manufactures which provide products, level second is e-shopping agencies which provide multiple products to the customers and level three denoted the customers (Jadhav & Bajaj 2015) [2].

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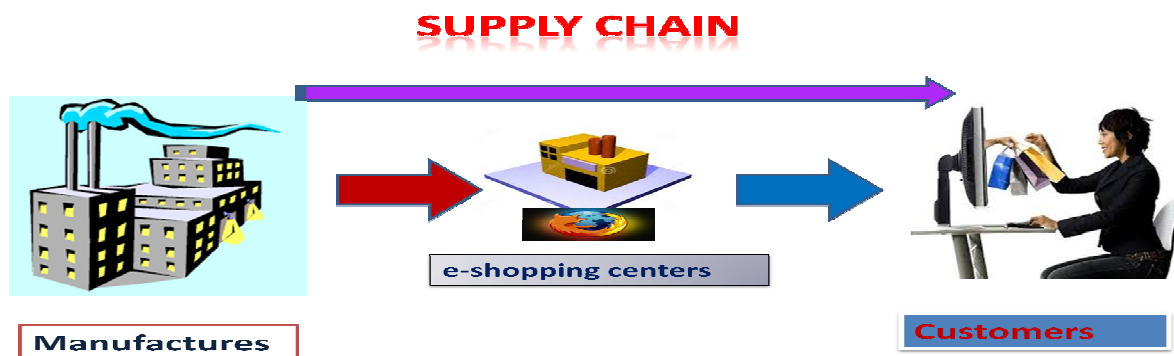


Fig. 1. The three level supply chain

A. Assumptions

1. There are multiple manufactures, e-shopping agencies, costumer's products and multi-channel systems.
2. Shortages and backordered are allowed at e-shopping agencies.
3. The prices for all products are fixed in the planning period.
4. The location of farm, suppliers, costumer and centres of e-shopping are known.
5. Products are stored at the e-shopping centre temporarily before delivery to the customers.
6. The capacity of the manufacturers, e-shopping centres are known.
7. All demands must be satisfied during the planning period.
8. Replacements of defective products are allowed.
9. Time for replacement is limited.
10. Demand assigned to the manufactures at the beginning of period.

III. MATHEMATICAL MODEL OF THE PROBLEM

In order to develop the mathematical model the following notations are used

Indices:-

j manufactures	$j = 1, 2, \dots, J$
k e-shopping centres	$k = 1, 2, \dots, K$
l customers	$l = 1, 2, \dots, L$
n products	$n = 1, 2, \dots, N$

Parameters:-

PC_{njt}	: Cost of n products from j manufactures in period t.
TC_{njkt}	: Transportation cost of each n products from j manufactures to k e-shopping centres in period t.
TC'_{nklt}	: Transportation cost of each n products from k e-shopping centres to l customers in period t.
TC''_{njlt}	: Transportation cost of defective n products from j manufactures to l customers in period t.
TC'''_{mt}	: Transportation cost of m defective products in period t.
RC_{mt}	: Replacement cost of m defective products from in period t.
h_{nkt}	: Holding cost of n products at k e-shopping centres in period t.
h'_{mt}	: Holding cost of m defective products in period t.
RT_m	: Replacement time of m defective products.
SC_{nkt}	: Shortage cost of n products at k e-shopping centres in period t
IC_t	: Indirect cost (such as packing cost, maintenance cost etc) in period t
q_{nkt}	: Inventory available of n products at k e-shopping centres.
d_{nlt}	: Demand of n products by l customers .
a_{kt}	: Total holding capacity of k e-shopping centres for n product in time period t
a_{nkt}	: Holding capacity of k e-shopping centres for n product in time period t
S_{njt}	: Supply capacity of j manufactures for n product in time period t
v_{njt}	: Delivery lead time of n product from j manufactures to k e-shopping centres.

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v'_{nkl} : Delivery lead time of n product from k e-shopping centres to l customers.
 v''_{njl} : Delivery lead time of n product from j manufactures to customers l.

Variables:-

Y_{njkt} : Amount of n products transported from j manufacturers to k e-shopping centres in period t.
 W_{nklt} : Amount of n products transported from k e-shopping centres to l customers in period t.
 X_{njlt} : Amount of n products transported from j manufacturers to l customers in period t.
 BO_{nt} : Amount of back order n products in period t.
 Df_{mt} : Amount of m defective products for replacement in period t.

A. Mathematical Formulation:-

$$\begin{aligned} \text{Min } Z_1 = & \sum_n \sum_k \sum_t h_{nkt} \left(\sum_j Y_{njkt} - \sum_l W_{nklt} \right) + \sum_m \sum_t h'_{mt} Df_{mt} \\ & + \sum_m \sum_t RC_{mt} Df_{mt} + \sum_n \sum_j \sum_k \sum_t TC_{njkt} Y_{njkt} + \sum_n \sum_k \sum_l \sum_t TC'_{nklt} W_{nklt} \\ & + \sum_n \sum_k \sum_l \sum_t TC''_{njlt} X_{njlt} + \sum_m \sum_t TC'''_{mt} Df_{mt} + \sum_n \sum_t SC_{nt} BO_{nt} + \sum_t IC_t \end{aligned} \quad \dots \dots \dots (1)$$

$$\text{Min } Z_2 = \sum_t \left(\sum_n BO_{nt} - \sum_m Df_{mt} \right) \quad \dots \dots \dots (2)$$

Subject to constraints

$$\sum_j \sum_n Y_{njkt} \leq a_{kt} \quad \forall k, t \quad \dots \dots \dots (3)$$

$$\sum_j Y_{njkt} \leq a_{nkt} \quad \forall n, k, t \quad \dots \dots \dots (4)$$

$$\sum_m Df_{mt} \leq \sum_l d_{nlt} \quad \forall l, t \quad \dots \dots \dots (5)$$

$$\sum_j \sum_t Y_{njkt} \geq \sum_l \sum_t W_{nklt} \quad \forall k, n \quad \dots \dots \dots (6)$$

$$\sum_j \sum_t Y_{njkt} - \sum_l \sum_t W_{nklt} = \sum_t q_{nkt} \quad \forall k, n \quad \dots \dots \dots (7)$$

$$\sum_j \sum_t Y_{njkt} = \sum_l \sum_t W_{nklt} \quad \forall k, n \quad \dots \dots \dots (8)$$

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$$\sum_j Y_{njk} v_{njk} + \sum_l X_{njl} v''_{njl} \leq S_{njt} \quad \forall n, k, t \quad \dots \dots \dots (9)$$

$$\sum_k \sum_t W_{nkl} + \sum_j \sum_t X_{njlt} \leq \sum_t d_{nlt} \quad \forall l, n \quad \dots \dots \dots (10)$$

$$\sum_k \sum_t W_{nkl} + \sum_j \sum_t X_{njlt} - \sum_t d_{nlt} = BO_{nt} \quad \forall l, n \quad \dots \dots \dots (11)$$

Objective function (1) minimizes the total costs of the supply chain, including the holding cost at the e-shopping centres, defective good storage, transportation cost from the manufacturers to the e-shopping centres, transportation costs from the e-shopping centres to the customers, transportation costs from the manufacturers to customers and indirect costs etc. Objective function (2) obligates the JIT delivery and minimizes the sum of backorder and amount of replacement products in all periods.

Constraints (3) and (4) denote the delivery capacity limitations of the e-shopping centre for all types of products and each type of product, respectively. Constraint (5) examines the amounts of shortage at the customers due to defective goods (replacement product). Constraint (6) explains how the total demands during the planning horizon are supplied. Constraints (7) and (8) represent the inventory at the e-shopping centres. Constraint (9) shows the balance between the total inputs and outputs of goods moving to and from the e-shopping centres during the planning horizon. Constraint (10) represents the complete satisfaction of total demands during the planning horizon. In other words, the total amount of products sent to the customers during the planning horizon should be equal to their total demands. Constraint (11) represents the backordered or excess amounts of products delivered to retailers in each period.

IV. METHODOLOGY

A. Genetic Algorithm

Genetic Algorithm, which is a very new approach for problems related to optimization. There are many techniques used to optimize a function but in case of optimizing Multimodal Functions most of these techniques face a common problem of robustness. These can be overcome by using Genetic algorithm.

Genetic Algorithms (GA) are direct, parallel, stochastic method for global search and optimization, which imitates the evolution of the living beings, described by Charles Darwin. GA are part of the group of Evolutionary Algorithms (EA). The evolutionary algorithms use the three main principles of the natural evolution: reproduction, natural selection and diversity of the species, maintained by the differences of each generation with the previous. Genetic Algorithms works with a set of individuals, representing possible solutions of the task. The selection principle is applied by using a criterion, giving an evaluation for the individual with respect to the desired solution. The best-suited individuals create the next generation.

B. The Algorithm

In the genetic algorithm process is as follows:

- Step 1 : Determine the number of chromosomes, generation, and mutation rate and crossover rate value.
- Step 2 : Generate chromosome-chromosome number of the population, and the initialization value of the genes chromosome -chromosome with a random value.
- Step 3 : Process steps 4-7 until the number of generations is meet.
- Step 4 : Evaluation of fitness value of chromosomes by calculating objective function.
- Step 5 : Chromosomes selection.
- Step 5 : Crossover.
- Step 6 : Mutation.
- Step 7 : New Chromosomes (Offspring).
- Step 8 : Solution (Best Chromosomes).

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C. Fuzzy Approach

The genetic algorithm consists of objectives and constrains values with fitness function, fitting that are represented by using single exact value. Further Fuzzy sets represented and computed by the single-point representation and computation. Fuzzy sets permits the values in GA expressed in range value with membership function embedded on it. With the help of membership function, triangular fuzzy number or Gaussian representation method the strict threshold valued computational models changed into fuzzy computational models. It allows for the use of fuzzy members and it preserves the nature of values and accuracy during computational processes.

Also, fuzzy logic can be used to select the most presented solution or final solution for implementation from these non-dominated solutions suggested by the genetic algorithm. By using fuzzy preference relation the non-dominated solution alternatives are compared in a pair. The solution is then derived from the pair-wise preference relation matrix by using direct approach. A fuzzy support concept, which is similar to the fuzzy core concept, is used to identify the alternatives, which are supported by the decision makers.

D. Intelligent Decision Support System:

Intelligent Decision Support System (IDSS) which consists of a combination of a multi-objective genetic algorithm and fuzzy logic [15]. The structure of IDSS is given in figure 2.

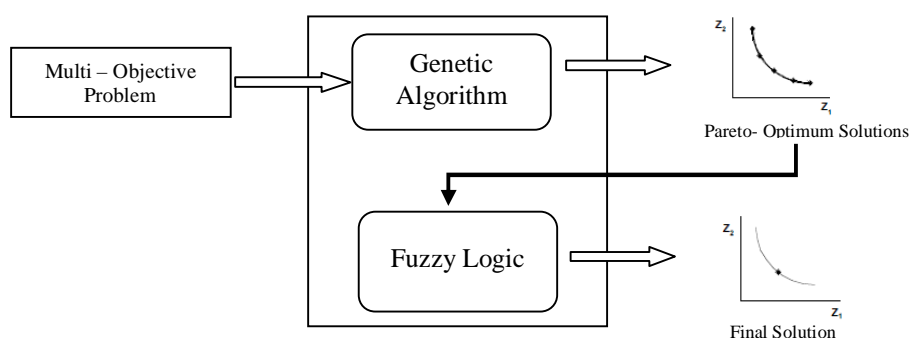


Figure 2. Configuration of Intelligent Decision Support System

Figure 2 demonstrate for multi objective problem a genetic algorithm is used at first level to create a Pareto-front that consists of non-dominated solutions. Then a fuzzy logic used to select the most preferred solution or final solution for implementation from these non-dominated solutions.

V. CONCLUSION

E-shopping is one of the most interesting and exciting aspects of evolution which is emerging in e-business. It is a main stream and feasible alternative to traditional methods of businesses being conducted today. Recently, customers are conscious about products and manufacturers move quickly to meet demands quick order fulfilment and fast delivery. Various e-shopping agencies follow different supply network strategies. A recent development in the supply chain is just-in- time distribution, also known as JIT. The just-in-time is a methodology aimed primarily to reduce flow times within production as well as response times from suppliers and to customers. That's why JIT can be a great solution for supply chain to maximize the efficiency and minimize the risk.

We have proposed a model for e-shopping business in a three- level supply chain system. This model not only minimizes the costs of production, holding, transport and indirect costs but also follows JIT distribution. Genetic algorithm with fuzzy approach will be provides high efficiency of the proposed model.

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