DESIGNING TWO-ECHELON SUPPLY CHAIN USING SIMULATION AND PRICING STRATEGY

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ABSTRACT

In this paper a two- echelon supply chain, including manufacturers and retailers have been considered. We have opened centers for manufacturers and retailers to set; we also considered how to determine the allocation of suppliers to retailers and the order amount of each retailer to maximize the whole profit of the supply chain. Our strategy in this paper is to determine the profit considering the unit price and revenue sharing; we also used simulation to estimate the transportation cost in the supply chain. Transportation cost for each vehicle is regarded with different costs during the loading, unloading and journey events according to discrete event simulation. Defined model for supply chain has been solved by simulating annealing (SA) algorithm.

Keywords: Supply chain, Discrete-event simulation, Simulated Annealing, Pricing

1. INTRODUCTION

A supply chain (SC) consists of all companies involved in the procurement, production, distribution and delivery of a product to a customer. Because different economic entities participate in the SC, it is significantly more complicated to manage than a single organization (Chaharsooghi and Heydari). From an operational perspective, SCM is to effectively integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide cost while satisfying service requirements (Simchi-Levi, Kaminsky et al. 2003).Revenue management is the use of pricing to increase the profit generated from a limited supply of supply chain assets. To increase the total margin earned from these assets, managers must use all available levers, including price. Revenue management adjusts the pricing and available supply of assets to maximize profits. Revenue management has a significant impact on supply chain profitability when one or more of the following four conditions exist:

1. The value of the product varies in different market segments.
2. The product is highly perishable or product wastage occurs.
3. Demand has seasonal and other peaks.
4. The product is sold both in bulk and on the spot market (Sunil 2010).

As supply chain members are often separate and independent economic entities, a key issue in SCM is to develop mechanisms that can align their objectives and coordinate their activities so as to optimize system performance (Li and Wang 2007). Coordination within a supply chain is a strategic response to the problems that arise from interorganizational dependencies within the chain. A coordination mechanism is a set of methods used to manage interdependence between organizations.

Given the increasing importance of high-performance supply, and the advantages to be gained through supply chain coordination, the challenge to an organization is how to select the appropriate coordination mechanism to manage organizational interdependencies (Fugate, Sahin et al. 2006; Xu and Beamon 2006).

Supply chain coordination improves if all stages of the chain take actions that together increase total supply chain profits. Supply chain coordination requires each stage of the supply chain to take into account the impact its actions have on other stages. A lack of coordination either occurs because different stages of the supply chain have objectives that conflict or because information moving between stages is delayed and distorted. Different stages of a supply chain may have conflicting objectives if each stage has a different owner. As a result, each stage tries to maximize its own profits, resulting in actions that often diminish total supply chain profits (Sunil 2010).

Today, in many papers like another paper of same authors in various areas the simulation is used(Kazemi and Taki 2012; Taki and Kazemi 2012). One of the powerful tools is discrete-event simulation (DES) model. Companies and manufacturers can use it to perform analyses to estimate the impact of their decisions performance on the overall before they made any real system changes(Kazemi and Taki 2012).

2. PROPOSED MODEL

2.1. Problem definition

Consider a two-echelon supply chain, including suppliers and retailers; there are some predefined place to set up Suppliers and retailers, supplier (manufacturer) produces the product internally under capacity limits. We have one kind of product and all vehicles are the same, The average cost of transportation depends on travel time, mean of waiting time, and the service of loading and unloading queues. In our simulations, we solve the following four events:

1. The event of traveling from supplier i to retailer j
2. The event of traveling from retailer j to supplier i
3. End of unloading event for j
4. End of loading event for j

2.2. Equations, Figures and Tables

Each open retailer can only connect to one supplier. Demand is a function of price and varies for each retailer linearly. The product unit sales price is the same for the entire chain.

Determining which of i and j are open and their relationship. Determining the product unit price Determining the order amount of any j to i.

Table 1: Notations

Index	
Manufacturers Index (1,2,…,N)	i
Manufacturers Index (1,2,…,M)	j
Parameters	
Dj(P)	Demand function of each retailer
Ci	Unit production cost of producing product i
hj	Iinventory costs per unit of product j for retailer
Aj	Fixed ordering cost retailer j
Qr	Maximum capacity of transportation
Bi	Fixed setup cost of manufacturer i
Ej	Fixed setup cost of retailer j
CAPi	Production capacity of i
Decision Variables	
Xij	Existence or nonexistence of communication between manufacturer i and retailer j
Ui	Manufacturer i is open or closed (1 if it is open, otherwise 0)
Vj	Retailer j is open or closed (1 if it is open, otherwise 0)
P	Product unit sales price (fixed value for the entire chain)
Qj	Order of each retailer
Mij	The transportation costs per unit for transportation from manufacturer i to retailer j (It is obtained by DES)

Demand is a function depending on the price and defined for each retailer as:

$$D_j(P)=\begin{cases}\alpha_j-\beta_j P & 0\le \mathrm{P}\le \alpha_{\mathrm{j}}/\beta_j\\ 0 & \mathrm{P}\ge \alpha_{\mathrm{j}}/\beta_j\end{cases} \qquad (1)$$

Objective Function.

$$Max f=\sum_{j=1}^{N}PD_j(P)V_j-\sum_{i=1}^{M}\sum_{j=1}^{N}C_iD_j(P)X_{ij}U_iV_j-\sum_{j=1}^{N}h_j\frac{Q_j}{2}V_j- \qquad (2)$$
$$\sum_{j=1}^{N}A_j\frac{D_j(P)}{Q_j}V_j-\sum_{i=1}^{M}\sum_{j=1}^{N}M_{ij}\left\lceil\frac{Q_j}{Q_r}\right\rceil\frac{D_j(P)}{Q_j}X_{ij}U_iV_j-\sum_{i=1}^{M}B_iU_i-$$
$$\sum_{j=1}^{N}E_jV_j$$

Subject to:

$$\sum_{i=1}^{M}X_{ij}\le V_j \quad \forall \mathrm{j} \qquad (3)$$
$$X_{ij}\le U_i \quad \forall \mathrm{i,j}$$

There is relationship between i and j if they are open, it means Each retailer can only be connected to a supplier but the supplier can be connected to multiple retailers.

$$\sum_{j=1}^{N}Q_jX_{ij}U_iV_j\le CAP_i \quad \forall \mathrm{i} \qquad (4)$$
$$V_j,U_i,X_{ij}\in\{0,1\} \quad \forall \mathrm{i,j}$$
$$\mathrm{P},\mathrm{Q_j}\ge 0 \quad \forall \mathrm{j}$$

It should be noted that the amount of Qj is determined due to Economical order Quantity (EOQ).

The first term of objective function is the amount of sales, the second is production costs in manufacturer open centers, the third is inventory costs in open retailer centers, the forth is order cost for any open retailer, The 5th is Total transportation cost, the 6th is The cost of setting up manufacturing sites and the last is the cost of setting up retailers.

Mij function for every manufacturer and retailer is obtained from discrete event simulation.

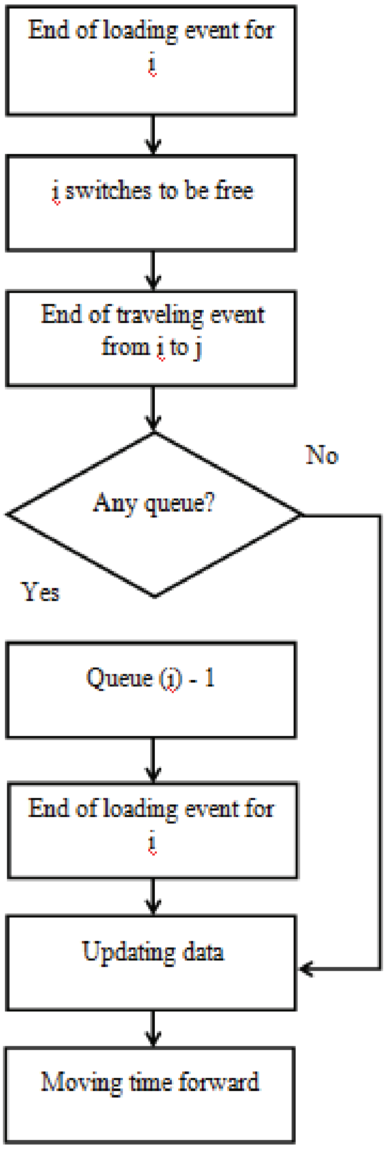

Fig.1 Flowchart of the simulation model for end of loading event

To obtain Mij :
Loading time in all the manufacturers are the same and have normal distribution with mean of 20 minutes and variance of 5 minutes.
Unloading time in all the retailers are the same and have normal distribution with mean of 15 minutes and variance of 3 minutes.
Traveling time will be divided into five groups with uniform distribution:

-U(120 min,150 min)
-U(100 min,130 min)
-U(70 min,90 min)
-U(30 min,50 min)
-U(90 min,110 min)

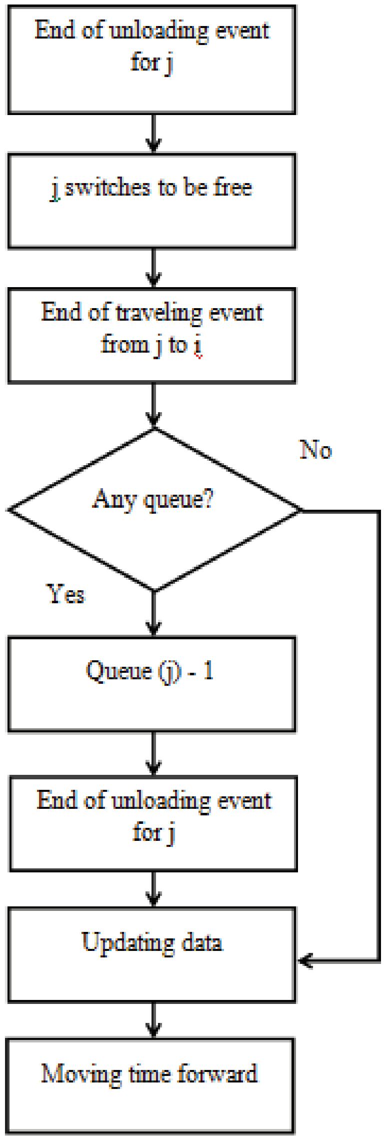

Fig.2 Flowchart of the simulation model for end of unloading event

3. RESULTS

We use SA algorithm to obtain an optimum solution of the objective function. The final result for the first objective was 516357.68.

As can be seen the stable solution is reached. To ensure an accurate answer, we compare the optimal solution with Genetic Algorithm(GA). As you see in Fig 2, the optimizing trend

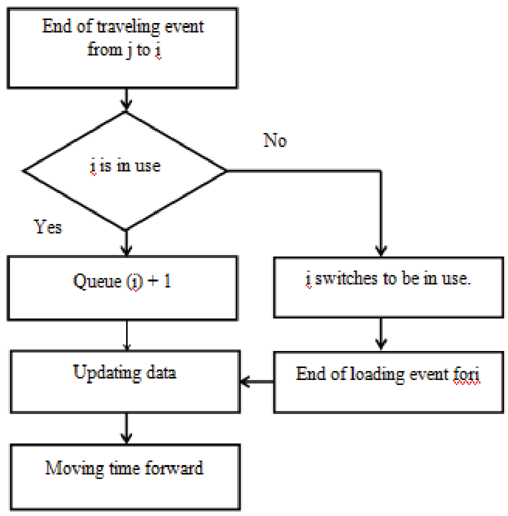

Fig.3 Flowchart of the simulation model for end of traveling event from j to i

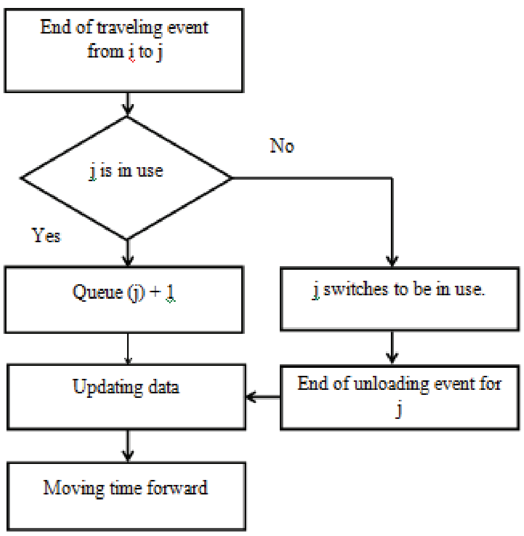

Fig.4 Flowchart of the simulation model for end of traveling event from i to j

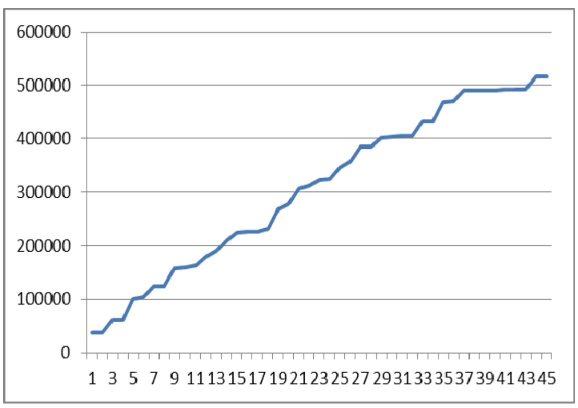

Fig.5 The results of using SA to find optimum solution

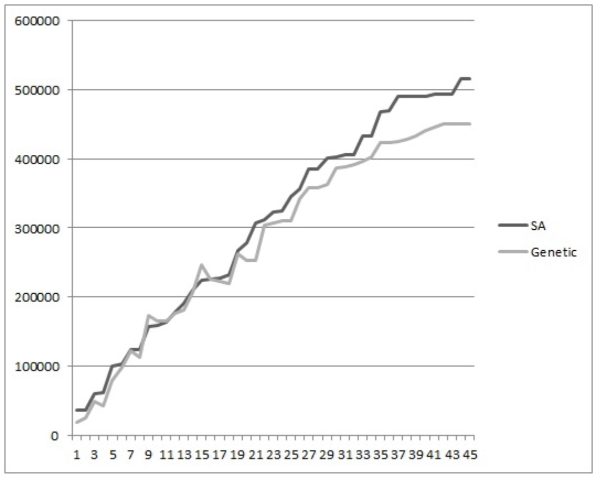

Fig. 6 The Comparison of SA algorithm solution with the Genetic Algorithm solution

4. CONCLUSION

Nowadays, many cases such as disruption, disasters, Perishable materials problem and some other topics are important for supply chain and pricing. In his paper, a two echelon supply chain has been design with regards to a assignment-order-pricing model. It has been considered that transportation cost for each vehicle is not a parameter. Therefore, discrete event simulation is used to evaluate the cost. Due to the important role of risk in supply chain, it is recommended to add risk minimization as an objective function. For next researches, we suggest to use the multi-objective models considering risk as an objective function.

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