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OPTIMAL SELECTION OF RETAILERS FOR A MANUFACTURING VENDOR IN A VENDOR-MANAGED INVENTORY SYSTEM WITH GENETIC ALGORITHM

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ABSTRACT: In this paper, we consider a two-leveled chain of supply that includes a manufacturer and a few retailers and in this chain VMI (Vendor-Managed Inventory) policy has been used. In this model, the manufacturer produces a limited amount of kind of production, and each retailer whose request is limited purchases the production with the wholesale price and sells it in retail price. In addition to the manufacturer's different decisions about selecting a retailer, and retailer's desire to join VMI system, simultaneously we have considered some other important variables such as wholesale price, retail price, and common timely cycle of the product. Our purpose in this article is to help the manufacturers select the retailers, which both covers the candidate retailer's answer and maximizes the interest of manufacturer and retailer. In order to find an optimized wholesale and retail price for both manufacturer and retailer, to find a common timely cycle for the replenishment of the retailer's production. In addition, to maximize the interest of manufacturer and the selected retailers, we have used genetic algorithm to solve the model, and to increase the effectiveness of this algorithm we have used the Regression way to adjust the parameters.

Keywords: Vendor managed inventory model. Optimal. Genetic.

1 INTRODUCTION

One of the issues, which has drawn the researcher's attention, is the management of supply in the last levels of supply chain. The management of the supply chain is an integration approach for programming and controlling the materials and information. The supply chain includes the operations related to production and distribution, transportation,

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warehouses and customers (CHOPRA; MEINDL, 2007).Considering the way of managing the supply in the levels of supply chain was the reason of doing the remarkable researches in this field. Some of these researches resulted in the policy of supply management by the manufacturer. The idea of VMI (Vendor-managed inventory) is a rollback model of replacing the goods in that the supplier is responsible to answer to the customer's request. In this model however it is the customer who should control the amount of his supply, the supplier does it instead (KUMAR; KUMAR, 2003).

VMI is a favorite strategy of the management of the supply through that a manufacturer is permitting to have the access to the information of his retailer's sale and the level of their supply. It is useful to execute VMI for both manufacturer and retailer (SAHIN; ROBINSON, 2002).

Whereas the manufacturer can manage the supply without distortion and can coordinate the delivery of products to different sellers, this coordination makes the seller able to have a common replenishing cycle for all the retailers in order to decrease the level of the supply and cost.

Selecting the retailers shows the process of manufacturer's decision taking in VMI system in that the manufacturer decides to accept a retailer or vice-versa. This is mostly true about the manufacturers with the limited capacity of production. The manufacturer, as a seller selects the retailers, and determines the demand of all selected retailers according to his production capacity.

Companies have acted in VMI (DISNEY; TOWILL, 2003) system as a competitive advantage to make their distribution chain better. This strategy was welcome especially in the grocery section but meanwhile it was used in different sections such as automotive, home appliances production, steel, book and petrochemicals.

2 VENDOR-MANAGED INVENTORY (VMI)

The initial conceptual structure of VMI was discussed by Magee in 1958 this way: Who is responsible to control the supply? However, the interest to VMI was really developed during 1990s. It is possible to classify what has been done based on VMI from 1990s:

1. To notice to the theoretical and practical management issues based on simulation approach (HOLMSTROM, 1998; DISNEY; TOWILL, 2002; TYAN; WEE, 2003).

2. To notice to the mathematical relations in the available academic places in this field and provide economic analysis (DONG, XU, 2002a).

Management of the supply by the seller is called cargo supply, which is largely used in the industry. Most of the retailers including WAL-MART store, KA-MART store, DILARD chain store and GC PENNY were vanguard in using VMI and they could get great profits (DONG, XU, 2002b).

Dong and Xu (2002b) presented a mathematical model in that it has compared traditional system with VMI system considering fixed demand, no shortage and the definite delivery time.

At the same time that they were following their studies in the short term and long term, they started surveying a situation in that the buyer’s and supplier's supply costs increases to less than traditional situation by using the new system (DONG; XU, 2002a).

Yao, Evers and Persner (2005) started comparing the traditional system with VMI system according to Dong an Yuls supposition, and supposing that the amount of manufacturer's order is an integral multiply amount of retailer's order (YAO; EVERS; DRESNER, 2007).

Kassilingam and Lee (1996) suggested a model of mixed programming of integral number according to the programming model of integral number to determine the sellers by determining amount of order to minimize the purchasing, transportation costs and receiving the components with less quality.

Degraeve, Labro and Roodhooft (2000) has formulated a model of selecting suppliers based on total cost of ownership. Ghosypour and O’brien (2001) provided a model of nonlinear multi criteria model of programming to solve the problem of multiple sources in choosing the sellers in order to minimize the total cost. They changed the model into a pure nonlinear programming model by ramifying the integral number variables, and they put their amount into the programming and solved it by Excel.

Some of the researches like Nachiappan and Jawahar (2007), Pasandide, Valizadeh (2010), Niaki and Nia (2011), Sadeghi, Saidi-Mehrabad (2011) , who provided nonlinear model in supply chain, used the innovative methods such as Genetic algorithm and Anil simulation algorithm.

According to the literature review, is perceived that we didn't focus on choosing the retailers in the policy of supply management by manufacturer. In this article the problem of choosing the retailers in order to maximize the profit of the manufacturer and retailer, and also achieving to an optimized common cycle to answer to the selected retailer's request was modeled and then solve it by using an over innovative Genetics algorithm.

3 DESCRIBING THE PROBLEM

This problem has a two-leveled chain of supply, which includes a manufacturer and some retailers. In this status, the management of the supplies is done in an integrated way through a "special production supply chain" and the manufacturer is responsible to decide about the supplies.

We want to choose some retailers among the candidates to maximize the profit of retailers and manufacturer and to find a common replenishment cycle of the product for selected retailers. In this problem, there is a manufacturer and M retailers and, every retailer has limited request, and the manufacturer produces a kind of product limitedly.

Supposition and parameters of the problem are as follow:

Supposition of the problem:

- Manufacturer has the limitation of production capacity.
- Shortage is permitted.
- Manufacturer produces just one kind of production.
- The amount of request for each retailer is limited.

For each retailer we suppose if the retailed price that is obtained by the manufacturer is in the special intervals (it's determined according to the retailer's costs) that retailer agrees to join to the VMI system.

3.1 The parameters of the problem

The used symbols in the problem for the retailers *i* = 1, 2, 3…, m are as follow:

M: The number of all candidate retailers

a_i :The rate of the *i* retailer request in the retailer's request integral.

P: The capacity of production, manufacturer

c_m : manufacturer's cost of production for each unit of production.

E_p: Manufacturer's expected profit for each unit of production.

E_i : The i retailer expected profit for each unit of production.

t: The necessary time for manufacturing a unit of production.

Hb_i : The cost of keeping each unit of production in *i* retailer warehouse in the unit of time.

H_P : The cost of keeping each unit of production in the manufacturer's warehouse in the unit of time.

K_i: The fixed amount depends on the *i* retailer, which shows the size of his market.

S_{bi}: The fixed cost of replenishment of the *i* retailer's production.

S_P: The cost of starting a production for the manufacturer

$\emptyset_i$: The cost of direct transportation of the production from the manufacturer to the *i* retailer.

ζ_i : The cost of supply that is paid to the manufacturer according to VMI policy by *i* retailer.

3.2 The manufacturer's variables for the decision

X_i: 0 or 1 variable, if *i* retailer is selected it is one otherwise it is zero.

C: Common cycle for the replenishment of the production.

C_p: The manufacturer's whole price of the production.

3.3 Each retailer's variables for the decision

P_i: The *i* retailer price for each unit of the production.

Y_i= It is 0 or 1 variable, which shows retailer's tendency to join to VMI system. If the i retailer decides to join to this policy it is 1, otherwise it is zero.

In this problem, after choosing the retailers by the manufacturer, if the retailed price of *i* retailer is (Equation 1):

$$P_i \geq \left(\frac{E_i}{2}\right) + \varnothing_i + Hb_i + \zeta_i + S_{bi} + C_p \tag{1}$$

The retailer accepts to join to this policy and Y_i= 1, otherwise Y_i=0.

Functions:

$Di(Pi)$ the amount of *i* retailer's request that is a function of the retailed price (Equation 2).

$$Di(Pi) = P_i(-a_i * P_i + K_i \tag{2}$$

NP_m : The manufacturer's net profit.

NP_{bi} : The i retailer's net profit.

TDC_p: The manufacturer's direct costs.

TIC :Total costs in the policy.

TIC_{b_i}: Total costs of the supply in *i* retailer's supply.

TIC_p: The cost of the supply in the manufacturer's warehouse.

TR_m : The manufacturer's income.

The manufacturer's net profit is obtained by reducing the costs from the incomes. The amount of manufacturer's income includes two parts, first part is the amount of selling his production to the selected retailers in the wholesale price, and the second part is the cost, which is paid to the manufacturer by the retailers for managing his supply, generally equals to (Equation 3):

$$TR_M = \sum_{i=1}^{m} X_i D_i (P_i)(C_p + \zeta_i) \quad (3)$$

The costs of the supply in this policy equals to the cost of production supply in the retailer's warehouse (TIC_{b_i}) and the costs of production supply in the manufacturer's warehouse (TIC_p).

The fixed cost of this policy for each retailer in each cycle equals to S_{bi} and the cost of keeping for each retailer equals (Equation 4):

$$Di(P_i).C^2.H_b i / 2 \quad (4)$$

So the cost of supply for each retailer in the unit of time equals to:

$$TIC_{bi} = \frac{x_i}{C}\left\{S_{bi} + Di(P_i).C^2.H_{bi} / 2\right\} \quad (5)$$

The cost of supply for the manufacturer in each unit of time equals (Equation 6):

$$TIC_p = \frac{1}{C}\left\{S_p + H_p \sum_{i=1}^{m} x_i Di(Pi)^2 C^2 / 2P\right\} \quad (6)$$

The direct costs of the manufacturer including the cost of the production and the transportation equals (Equation 7):

$$TDC_p = \sum_{i=1}^{m} X_i D_i (P_i)(C_m + \phi_i) \quad (7)$$

3.4 The problem simulation

The manufacture’s net profit equals:

$$NP_m = TR_m - \sum_{i=1}^{m} TIC_{bi} - TIC_p - TDC_p = \sum_{i=1}^{m} X_i D_i(P_i)(C_p + \zeta_i) - \frac{1}{C}\sum_{i=1}^{m} x_i \{S_{bi} + Di(P_i).C.H_{bi}/2\} - \frac{1}{C}\left\{S_p + H_p \sum_{i=1}^{m} \frac{x_i Di(Pi)^2 C^2}{2P}\right\} - \sum_{i=1}^{m} X_i D_i(P_i)(C_m + \phi_i) \quad (8)$$

So according to the manufacturer's net profit we can show the model as follow (Equation 9):

$$\text{Maximize} = NP_m(C_p, X, C) \quad (9)$$

Subject to (Equations 10-17):

$$\sum_{i=1}^{m} X_i D_i(P_i) \le P \quad (10)$$

$$C_m + H_p + S_p \le C_p \le C_m + H_p + S_p + E_p \quad (11)$$

$$\sum_{i=1}^{m} D_i \text{t} \le \text{ C} \le \text{Pt}, \quad (12)$$

$$(C_p + \zeta_i + Q_i + Hb_i \le P_i \le C_p + \zeta_i + Q_i + Hb_i + E_i), \ \text{i} = 1, \ldots, \text{m} \quad (13)$$

$$Y_i(P_i - C_p - \zeta_i) \ge 0, \ \text{i} = 1, \ldots, \text{m} \quad (14)$$

$$Y_i D_i(P_i) \ge 0, \ \text{i} = 1, \ldots, \text{m} \quad (15)$$

$$X_i \le Y_i, \ X_i = \{0,1\}, \ \text{i} = 1, 2, \ldots \text{m} \quad (16)$$

$$Y_i = \{0,1\}, P_i \ge 0, \text{i} = 1, \ldots, \text{m} \quad (17)$$

4 SOLVING THE MODEL BY GENETIC ALGORITHM

All of the input parameters of Genetic algorithm, which are used to solve the model, will be described as follows.

4.1 The input parameter of Genetics Algorithm

The number of repetitions of the algorithm (Maxlt): We considered the amount of this parameter 100.

The amount of population in each repetition (NPOP): in each repetition, the amount of population is considered 100.

The rate of compound: (PC) The rate of compounding of the chromosomes is considered 0.6.

The rate of mutation (PM): The rate of mutation of the chromosomes is considered 0.04.

4.2 Determining chromosome

The first step to solve the problem is determining the structure of the chromosome. As know each chromosome in the genetic algorithm equals one of the possible statuses of the problem status.

In this problem we assume the chromosome as one-dimensional presentation provided with the length of $2I + 2$ (I is the number of candidate retailers). The first part of this presentation (from $i = 1$ to $i = I$) is assigned to 1and 0 variables of *x*, and the second part of this presentation($i = I + 1$ to $i = 2I$) is assigned to the continual variable of the retailer's price. In addition, the element $2I + 1$ is assigned to the continual variable of the wholesale price, and the element $2I + 2$ to the continual variable of the cycle of time, i.e.:

x_1	x_2	. . . .	x_m	p_1	. . . .	p_m	C_p	C

4.3 To make the initial population or the first generation

As know we can create the initial population accidently. The number of the chromosomes in the initial population is considered 100 in the written code. If we can select the initial population in a way that has some of the conditions while they are accidental we can certainly get the answer faster, because the better the initial population is, the faster we have access to the answer. According to this idea, we selected the initial population in a way so that some limitations of the problem are solved.

We have accidently selected "*I*" number of first element that belonged to the 0 and 1 of the *x* and with the rand function and also to keep the limitations the element $I + 1$ to $2I$ that belongs to the continual variable Pi (retailed price) is chosen accidently and the as follow (Equation 13):

$$C_p + \zeta_i + Q_i + Hb_i \leq P_i \leq C_p + \zeta_i + Q_i + Hb_i + E_i \tag{13}$$

Moreover, the following relations are used to choose the elements 2I+2 & 2I +1, which respectively belonged to the wholesale price and the common cycle of time (Equation 11 and 12):

$$C_m + H_p + S_p \leq C_p \leq C_m + H_p + S_p + E_p \tag{11}$$

$$\sum_{i=1}^{m} D_i \mathrm{t} \leq \mathrm{C} \leq \mathrm{Pt} \tag{12}$$

4.4 To make the function of value

In the following studies a function should be made makes us able to assign a number to each member of the population, which shows how good he is. The function that is called "Fitness" is considered the goal the function of the problem.

4.5 To combine the samples and make a new answer

In the following two samples should be chosen and after combining each of them two new answers should be obtained.

By choosing two accidental numbers we choose two samples and of course these accidental numbers should be in a way that the samples have the more function of value have more chances than the other members of the population to be chosen. Here the technique of Rolt wheel is used. And we used the replacement method to obtain parent chromosome. However, not only combining action is enough to conduct us to the final answer but also it's necessary to use mutation action as well.

First, a number between 0 and 1 is chosen. If the chosen number is less than the rate of mutation (is equal to 0.001), the mutation isn't done, but if the number is more than the rate of mutation, by using the function of selection we choose a chromosome which should be mutated is determined and then mutation will be done.

4.6 To evaluate population of answers

Now we have a population of the answers that certainly some of them are better than the others are and as we know to create the next generation those answers are more valuable than the others should be used. This way we should evaluate our answers in the following. This action is exactly the function of fitness but this time this population evaluates the answer.

4.7 To create the next generation

Here we should select the best answers among the answers as the next generation's parents and throw the others away by using the Rolt Wheel.

4.8 The condition for stopping

The algorithm is just stopped when it reaches to the predetermined maximum repetition.

4.9 To set the parameter

As we know the input parameters of the Genetic algorithm are the number of repeating the algorithm (maxtl), the amount of the population in each repetition (popsize), the rate of the compounding (pc), and the rate of mutation. The assumed variable for optimization here, the best obtained answer from the algorithm, is in the last repetition.

To determine the parameters 30 examinations were done by changing the amount of the parameters, which are shown in the Table 1.

Table 1 – The table of amounts of parameters

Parameter	**Min**	**Max**
Popsize	80	120
Pm	0	0.05
Pc	0.4	0.8

In this, level we have done a model of Regression (nonlinear- quadratic) by excel to estimate the most desirable form of relation among the parameters and the obtained regression model is as follow:

$$Fitness\ (GA) = -\frac{1349404}{623(Npop)} - 367400000(Pm) + 6525130/547(Pc) - 23900000(Pc)^2 - 2709000000(Pm)^2 + 5732/503(Npop)^2 + 34010000(Pc)(Pm) + 219245/358(Pc)(Npop) + 5122283/779(Pm)(Npop)$$

Now that the relation between amount of fitness and the parameters *Npop*, P_c and P_m are determined, the optimum amount of these parameters should be achieved so that the best amount for the value function can be acquired. I.e., the optimum model of the Genetic Algorithm

$$Fitness(GA) = -1349404/623(Npop) - 367400000(Pm) + 6525130/547(Pc) - 23900000(Pc)^2 - 2709000000(Pm)^2 + 5732/503(Npop)^2 + 34010000(Pc)(Pm) + 219245/358(Pc)(Npop) + 5122283/779(Pm)(Npop)$$

Subject to:

$80 \leq Popsize \leq 120$

$0 \leq Pm \leq 0.05$

$0.4 \leq Pc \leq 0.8$

Popsize: Integer

Pm, Pc: constant

The optimum amounts of the obtained parameters are shown in Table 2.

Table 2 – The optimum amount of parameters of the algorithm

GA paramerers	Popsize	Pc	Pm
Optimal Value	80	0.4	0.007

According to the above mentioned parameters the amount of the function is obtained 10000000000.

5 CONCLUSIONS

According to the supply management by the seller, the manufacturers today are looking for the ways to choose some retailers among many of the candidate ones to sell their productions with the suitable price by paying attention to amount of their production. If there are many candidate retailers, the manufacturer needs more time and cost to choose his considered retailers. Therefore, he needs to have a correct planning and modeling to be able to choose his desirable retailers easily and in a short time to be sure for having the profit.

According to this paper, it can be said that in the manufacturer's supply management system it is so important for the manufacturer to know the retailer who he is selling his productions gives him the maximum profit in the wholesale price.

In this modeling in addition to the manufacturer's profit, every selected retailer's profit increases to the maximum level and this is an important criterion of the retailers to join to this policy. According to this model, every candidate retailer can easily decide about joining to this policy and in the case they, join to this policy, they will have a desirable profit. Furthermore, in this article with the modeling and the hypothesis we had we could get a common timely cycle for all the selected retailers to help the manufacturer decrease the transportation costs.

In the next research, we try to:

- To make the model more real by decreasing the simplifying suppositions
- Another over innovative Algorithm can be used and compare its efficiency with Genetic Algorithm.
- It’s also possible to develop the levels of supply management.

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