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Analysis of Permissible Delay in Payment Policy for Sustainable Business Development

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Abstract

Many retailers in developing countries have difficulty to make direct payment. As a consequence, the vendor has to offer delay in payment to keep sustainable order from his retailers and to attract the retailers to order larger quantity. In the other side, the vendor financial position has to be preserved to keep their financial safety. When time value money is considered, retailers get some additional profit from interest earned and the vendor get loss from interest cost. In this situation, the vendor wants to maximize his profit and financial health. In this paper, we develop a model of one vendor and many retailers with delay in payment and considering time value of money. Since the vendor has two contradictive goals, goal programming approach is used in the model and Genetic Algorithm (GA) approach is employed to solve the problem. A numerical example and sensitivity analysis with different retailer demand, retailer payment ability and vendor credit limit are shown to illustrate the model. The results show that vendor prefer to delivers products to retailer with high payment ability to achieve his goals.

Keywords
Sustainable business, delay of payment, time value of money, optimization

1. Introduction
In today economy situation many organizations struggle to have sustainable business. Many retailers, especially in developing countries, have financial problems. They ask their vendor for delay in payment. Although delay in payment will affect the vendor financial balance, but the vendor will agree with delay in payment structure to keep sustainable order and attract retailers to order more. In this paper we want to analyze the effect of delay in payment for vendor by considering the vendor's profit and the vendor's financial condition.

Researches about delay in payment have been conducted intensively in recent years since delay in payment affect retailer order quantity (Chung, 1998). Jamal *et al.* (2000) developed a deteriorating inventory model considering credit period to the retailer for payment without penalty. They found that the retailer always choose an option to pay after the permissible credit period. Teng *et al.* (2005) analyzed the effect of permissible delay in payments with difference between selling price and purchase cost for one retailer and one supplier. They concluded that the order quantity and economic replenishment interval generally increases under permissible delay in payments. Carter and Auken (2005) concluded that a business prefers to involve permissible delay in payments when risk level appears high to minimize his accounts receivable. Yang and Wee (2006) found that permissible delay in payment is a win-win strategy for sharing profit in a collaborative strategy. Shah (2006) analyzed deteriorating inventory model by considering permissible delay in payments and time value of money. An integrated vendor retailer model by considering permissible delay in payment and profit sharing was developed by Jaber and Osman (2006). Jaggi and Khanna (2009) analyzed retailer's procurement policy under the effects of permissible delay in payments, inflation and time value of money. Darwish and Goyal (2010) found that permissible delay in payments impact supply chain decisions such as vendors' production lot size and number of shipments. Most of research above only considered one objective function.

Genetic algorithm (GA) is a search method developed by Holland (1975) and it is inspired by natural biological evolution. Since the GA has quite good performance in reasonable computation time, it has been using to solve many problems. Genetic Algorithm (GA) method is one of heuristic methods that mimic the natural evolution process and has been used widely to solve NP-hard problems. GA has been used intensively in supply chain problems. Maiti *et al.* (2006) solved a constrained non-linear mixed-integer programming problem for multi-item inventory model with discount using GA. The GA in their paper used Roulette wheel selection, arithmetic crossover and non-uniform mutation. They concluded that the GA can be extended to solve other inventory models. Torabi *et al.* (2006) developed a supply chain model with lot and delivery scheduling. They formulated the problem as a mixed integer non linear program (MINLP) and solve it using a hybrid genetic algorithm. They incorporated a neighbourhood search into a basic GA. Pourakbar *et al.* (2007) developed a model and solution for four-stage supply chain system. They tried to get optimal order quantity for each stage in order to minimize total cost of the supply chain. They used GA to derive the solution. Pasandideh et al. (2008) used GA to solve a production inventory model for multi products, discrete delivery and constrained space. The problem is formulated as a non-linear integer programming model (NILP).Kannan *et al.* (2010) applied GA to solve a mixed integer linear programming model (MILP) for a closed loop supply chain model. The authors concluded that GA performs well in term of solution quality and computation time for large size problem.

Michaelraj and Shahabudeen (2009) analyzed replenishment policies with delay of payment and considering financial safety. They set two different objective functions, which are financial safety and maximizing total profit. We extend their model by combining the vendor's financial safety and maximizing total profit in one goal programming model and considering time value of money. Vendor likes to increase his profit by giving the retailers delay in payment; however he also has limited financial constraint. We will analyze percentage of supplier's demand that will be delivered by the vendor considering vendor's profit and financial condition. Number of items delivered by vendor depends on supplier credit that has been paid. In this paper we assume there are one vendor and few retailers that have different financial ability. In this paper, we try to analyze the benefit of delay in payment policy offered by vendor to his retailers. Section one explain the background of the problem and literature review. The mathematical model is formulated in Section 2. In Section 3, we describe the operators that are used in Genetic Algorithm. Section 3 shows a numerical example and some analyses of the calculation results and some interest conclusions and future research are shown.

2. Mathematical Model

In this model, we analyze a vendor strategy to handle some retailers using permissible delay in payment under varies payment ability. The vendor wants to maximize his profit and keep his financial safety. Some assumptions are using in this model as follows:

1. Retailer's demands are fixed in one contract period.
2. Retailer's payments are stochastic.
3. The payments policy has been set up in the contract and it cannot be changed during one contract period.
4. Contract period is fixed.
5. Suppliers have to pay all off their liability at the end of contract period.
6. Vendor has a right to decide number of products delivery if suppliers credit over the limit.
7. Vendor use lot for lot batching rules, so inventory cost can be ignored.

In this paper notations below are used:

C_v = vendor price per unit
$L_{i,j}$ = vendor delivery units to supplier *i* at time *j*
$D_{i,j}$ = demand of supplier *i* at time *j*
$B_{i,j}$ = credit of retailer *i* at time *j*
$P_{i,j}$ = payment of retailer *i* at time *j*
PR_i = percentage delivery to retailer *i*
S_i = credit limit for retailer *i*
U_j = percentage payment of retailer *j*
IE = vendor interest earned
VP = Total vendor profit
IR = total vendor interest cost

MP = maximum vendor profit
PAR = vendor's planned account receivable
dP^- = deviation of vendor's profit to the maximum profit
dF^- = deviation of vendor's cash flows
T = contract period
R = number retailers

In this model, the vendor goal is to minimize deviation of vendor profit and vendor cash flows. The normalized vendor's goal function can be modeled as follows:

$$Minimize\ z = \frac{dP^-}{MP} + \frac{dF^-}{PAR} \tag{1}$$

The vendor total profit is equal to total income minus interest cost and he wants to get profit as much as the maximum profit. The maximum profit can be derived if all retailers pay all of his order directly after the vendor deliver the products. The vendor total cost in T contract period and R retailers is:

$$\sum_{i=1}^{R}\sum_{j=1}^{T}(P_{i,j} - B_{i,j}IR) + dP^- = MP \tag{2}$$

The vendor also does not like to have too much account receivable. He set a target of account receivable and tries to minimize his total account receivable with his target. The account receivable goal can be modeled as follows:

$$\sum_{i=1}^{R}\sum_{j=1}^{T}B_{i,j} + dF^- = PAR \tag{3}$$

The vendor account receivable for retailer i at time j is equal to interest earned from previous period minus payment of retailer plus total selling value to retailer. The vendor account receivable van be modeled as follows:

$$B_{i,j} = IE(B_{i,j-1}) - P_{i,j} + C_v D_{i,j} \qquad \forall i,j \tag{4}$$

We assume that at the end of planning period, suppliers will pay all of his liability. One has:

$$B_{i,T} = 0 \quad \forall i \tag{5}$$

Due to budget limitation, the vendor has delivery policy for each retailer. If retailer credit position is under credit limit then the vendor will deliver equal to the retailer's demand, but if retailer credit is higher than the credit limit, the vendor only delivers a predetermined percentage number of retailer's demand. This situation can be modeled as:

$$L_{i,j} = \begin{cases} D_{i,j} & if\ B_{i,j} \le S_i \\ PR_i D_{i,j} & if\ B_{i,j} > S_i \end{cases} \tag{6}$$

Retailer payment ability can be divided in three categories which are low, medium and high. The payment ability will affect retailer payment. If retailer's credit is equal or smaller than retailer's credit limit, then retailers does not have to pay, otherwise retailers have to pay their liability as much as total liability minus credit limit. This condition can be modeled as follows:

$$P_{i,j} = \begin{cases} 0 & if\ B_{i,j-1} \ge S_i \\ U_j(C_v L_{i,j} + B_{i,j-1}) - S_i & if\ B_{i,j-1} > S_i \end{cases} \tag{7}$$

The percentage delivery rate of retailer i is set from 0 to 1.

$$0 \le PR_i \le 1 \tag{8}$$

3. Genetic Algorithm

In this paper, we use Genetic Algorithm method to solve the problem because the problem is too complex to be solved using analytical method. The genetic algorithm method is developed as follows:

3.1. Chromosome

The chromosome (allele) is a real and it is used to represent percentage delivery to retailer *i* (PR_i). The minimum value is zero and the maximum value is equal to 1. The chromosome is represented as binary and an example of chromosome is as follows:

1	2	3	4	5	6	7	8
0	1	1	0	0	1	1	0

The value of chromosome is equal to $(0x2^0+1x2^1+1x2^2+0x2^3+0x2^4+1x2^5+1x2^6+0x2^7)/355 = 102/355 = 0.287$

3.2. Initial population

The initial chromosome population is generated randomly and the population size is equal to 20. The initial chromosome consist of variable percentage delivery to retailer *i* (PR_i).

3.3. Evaluation of Fitness

A fitness function is calculated using the normalized vendor's goal function (eq. 1). The fitness function has to be minimized. The fitness function is calculated using some constraint as shown in equation 2 to 8.

3.4. The Parent Selection

The parent selection is used to pick two chromosomes as parents. Using the parents, we will generate two new chromosomes that are known as children. This model uses the roulette wheel method with lot size equal to their fitness for reproduction. Because the objective is to minimize revenue, a solution with a lower fitness value has greater probability to be selected.

3.5. Genetic Operators

Genetic operators are used to derive a better solution for each generation. Genetic operators consist of elitism, crossover and mutation. In this study, the population size is set at a constant through successive generation. In each generation, elitism is set and crossover and mutation are used to generate new children.

3.5.1. Crossover

Crossover is used to get better solutions around existing solutions. We used two points crossover function with crossover probability is equal to 0.8. In the two point crossover, two positions are picked randomly from parent chromosome and every allele between the two points of the parents is swapped. The example of two point crossover is shown below.

If we have two parents as below:

Parent 1

1	2	3	4	5	6	7	8
0	1	1	0	0	1	1	0

Parent 2

1	2	3	4	5	6	7	8
1	0	0	0	1	0	1	0

and the two point crossover have position 2 and 4, then we have two children as follows:

Child 1

1	2	3	4	5	6	7	8
0	0	0	0	0	1	1	0

Child 2

1	2	3	4	5	6	7	8
1	1	1	0	1	0	1	0

7.5.2. Mutation

Mutation is used to prevent the solutions trapped in local optimum solutions. The mutation scheme is uniform with mutation probability is equal to 0.05.In this scheme, one parent is picked randomly and one position picked randomly from the parents and then changed the value of the allele. The example of the mutation scheme is shown below. If we have one parent chromosome as:

Parent

1	2	3	4	5	6	7	8
0	1	1	0	0	1	1	0

and the mutation position is point to third position, then the value of third position is switched from 1 to 0, and we have new child as:

Child

1	2	3	4	5	6	7	8
0	1	0	0	0	1	1	0

3.6. Stopping Criterion

The stopping criterion for Genetic Algorithm depends on the number of generations. If the number of generations is greater than the value previously determined, then stop. We used 100 numbers of generations when the solutions have been convergence. In the next section, a numerical example is given to illustrate the theoretical results.

4. Numerical Example

We will use a numerical example to analyze the model. The numerical example data are generated randomly, however we consider all possibility situations in reality. We consider there are three types of retailer demands and retailer performance payments which are low, medium and high. All demand and payment are generated randomly following uniform distribution. Low demands are from 100 to 200 units, medium demands are form 300 – 600 units and high demands are from 1000 – 2000 units. Percentage of payments represents the financial ability of retailers to pay. Retailers with low ability to pay can pay 30% – 50% of his credit, medium ability retailers can pay 50% - 70% of his credit and high ability retailer can pay 705 – 100% of his credit. The detail data is shown in Table 1. The numerical example using ten business periods and since the retailer's payments are stochastic, we use 25 replications. The solution is derived using genetic algorithm (GA) method.

Table 1. Data for different retailer types

Retailers	**Demand**		**Payment**	
	Type	**Quantity**	**Type**	**% of payment**
1	Low	U(100-200)	Low	U(30-50)
2	Low	U(100-200)	Medium	U(50-70)
3	Low	U(100-200)	High	U(70-100)
4	Medium	U(300-600)	Low	U(30-50)
5	Medium	U(300-600)	Medium	U(50-70)
6	Medium	U(300-600)	High	U(70-100)
7	High	U(1000-2000)	Low	U(30-50)
8	High	U(1000-2000)	Medium	U(50-70)
9	High	U(1000-2000)	High	U(70-100)

We analyze the vendor goal and the vendor decision variables using different credit limit. We use credit limit for each retailers equal to one month, two months and three months of his average demand in one business period. The detail results can be seen in Table 2.

Table 2. The Vendor's goal and % of delivery for different credit limit

Retailers	1 month	2 months	3 months	Average
1	0	0	0.365	0.122
2	0.302	0.333	0.206	0.280
3	0.254	0.984	1	0.746
4	0	0.032	0.111	0.048
5	0.016	0	0.921	0.312
6	0.032	0.873	0.857	0.587
7	0	0	0.032	0.011
8	0	0	0.905	0.302
9	0.984	1	1	0.995
Total	0.176	0.358	0.600	

The vendor goal for one month credit limit is 1.475, 1 for two months credit limit and 0.773 for three months credit limit. It means when vendor offer bigger credit limit, then deviation of the vendor is lower. Table 2 shows that for one month credit limit, in average vendor only deliver 17.6% of his retailers demand. Percentage of product delivery increases as credit limit increases, however the vendor cannot send full delivery since there are credit limit constraint. The vendor delivers small percentage of demand for retailers with low demand with medium and high payment ability (retailer 2 and 3). The vendor does not deliver products to retailer with low payment ability (retailer 1). The vendor also does not take risk to deliver products to vendor with medium demand (retailer 4, 5 and 6). The vendor delivers almost full demand for retailer with high demand and high payment ability (retailer 9). However, the vendor does not want to take risk to deliver products to retailers with high demand but have low and medium payment ability (retailer 7 and 8). The vendor tends to deliver more products when he offers higher credit limit. Table 2 also shows that vendor prefers to delivers more products to retailers with good payment ability. In this model, retailers with high demand are not assured to get high percentage delivery if their payment ability is not high. The model shows that vendor delivers small quantity item to retailers with low payment ability and full quantity demand to retailers with high ability payment. When vendor has limited credit, for the long run permissible delay in payment will not gives benefit for retailers with low payment ability.

5. Conclusion

In this paper we analyze the effect of permissible delay in payment for one vendor and many suppliers by considering vendor profit and vendor account receivable goals. The model is solved using genetic algorithm method. A numerical example is used to analyze the model. The solutions show that credit limit affect vendor's goal and decisions. Vendor prefers to deliver more products to retailers with high payment ability to achieve his goals. In this model, retailers payment are generated randomly and the goals are analyzed only from vendor. In the future research, this model can be extended by considering retailer's goals. Different vendor-retailers policies such as integrated model and Stackelberg game also can be considered.

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