Using GA Approach to Solve a Deteriorating Inventory Model in a normal Marketing Channel

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***Abstract*—This study discusses how to use integrated marketing channel in order to reach the marketplace with lower cost or more profit, and how a framework for analysis can improve the channel decisions made by an executive acting as a channel manager or designer. This paper also proposes a manufacturer-distributor--retailer deteriorating inventory system that contains three levels of normal marketing channel. In order to achieve long-term benefits and global optimum of the system, the different facilities should develop their partnership through information sharing or strategic alliances. The mathematical model describes how the integrated approach to decision making can achieve global optimum by Genetic Algorithm (GA) method. The study provides managerial insights on the benefits of revenue management in a normal marketing channel through cooperation.**

Keywords*—Manufacture-distributor-retailer system; Deteriorating items; Marketing channel; Genetic Algorithm(GA).*

1. Introduction

Marketing channels are behind every product and service that consumers and business buyers purchase everywhere. Yet in many cases, these end-users are unaware of the richness and complexity necessary to deliver what might seem like everyday items to them. Usually, combinations of institutions specializing in manufacturing, wholesaling, retailing, and many other areas join forces in marketing channels.

In every channel, three fundamental stages of marketing channel, procurement, production and distribution, have existed independently as disconnected entities, buffered by large inventories. The inventory across the entire chain should be closely monitored because Inventory held to satisfy customer demand increases costs, thus decreasing profits. If we regard the term marketing channel as a buy-and-sell view of the business, both buyers and vendors may hold excessive safety stock of the same products to satisfy their respective customers.

Thus, enterprises are forced to develop channel cooperation that can respond quickly to customer needs with maximum service level. An integrated marketing channel inventory policy will lead to a decrease in costs for each player [2, 7]. [4] defined the marketing channels as: "Marketing channels are sets of interdependent organizations involved in the process of making a product or service available for use or consumption." Later, [12] commented on marketing as: "Establish channels for different target markets and aim for efficiency, control, and adaptability." And, he also defined the channel level and used the number of intermediary levels to designate the length of a channel. The general structure of a marketing channel consists of producer, distributor (wholesaler, jobber….), retailer and customer. There are different considerations on effect of channel performance with various level channels [12].

For lower level channels, a zero-level channel (also called a direct-marketing channel) consists of a producer selling directly to the final customer. A one-level channel contains one retailer. In these lower level channels, quality is the main consideration on effect of channel performance. For the intermediate level channel, a two-level channel containing two selling intermediaries is. And, the spatial issue is the key factor on effect of channel performance. For the high level channel, a three-level channel containing three selling intermediaries is. For example, in the meatpacking industry, wholesalers sell to jobbers, who sell to small retailers. So, the network relationship is the key factor in the high level channel.

Recently companies are increasingly taking a value network view of their business. Instead of limiting their focus to their immediate suppliers, distributors, and customers, they are examining the whole supply chain that links raw material, components, and manufactured goods and shows how they are moved toward the final consumers. Companies are looking at their suppliers' upstream and at their distributors' customers downstream. They always try to find a better way to improve the channel efficiency.

Research in the management of decaying or deteriorating items is important in marketing channel because in real-life, deterioration of items is not negligible. Deterioration is defined as decay, damage, spoilage, evaporation, obsolescence, pilferage, and loss of utility or loss of marginal value of a commodity that results in decreasing usefulness from the original one. The special characteristics of modern business make the inclusion of deterioration very significant.

This paper discusses how to use integrated marketing channels to reach the marketplace with lower cost or more profit approach, and how a framework for analysis can

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improve the channel decisions made by an executive acting as a channel manager or designer.

2. Literature Review

The economic order quantity (EOQ) model of [11] has been frequently extended by relaxing some of the original assumptions used. One of its key assumptions is that all costs in the model do not change during the foreseeable horizon. This assumption does not reflect the situation where inflation rate is high or the situation where price increase or decrease is expected. [10] compares the optimal order quantities determined by the average annual cost and the discounted cost over all future time. He knows that the discounted cost is almost less than average annual cost in the order quantities. [1] develops two deterministic models in calculating economic replenishment order sizes under two specific situations. Each situation is: (1) an optimum reorder before a step increase in purchase cost; and (2) optimum size of the next reorder will be subject to a constant rate of inflation. [15] develop a model to determine an optimal ordering policy for deteriorating items under inflation, permissible delay of payment and allowable shortage. [20] addressed a quick response production strategy with continuous demand and price declining. All these researches with cost or price change were based on the case of single echelon.

Many other researchers have studied on varying demand problem for deteriorating inventory. [6] were the first authors to issue deterioration item with pricing policy. [5] proposed a replenishment policy for an item with the no-shortage linear increasing trend demand. He designed an approach to determine the optimal number of replenishments and accordingly times. His Donaldson's computational approach requires complex calculations, so [16] proposed simpler approaches giving approximations optimal solutions. [17] considered the demand is depend on selling price to optimize prices and replenishments with shortage were permitted. [19] investigated a deteriorating inventory model in which demand is a decreasing linear function of selling price and designed a heuristic approach to derive a near optimal replenishment and pricing policy.

Compensation policy is very useful to increase profit of supply chain. [13] explored the two typical cases: supplier's dominance with large production lot sizes and shipment sizes and buyer's dominance with small frequent shipments. [3] analyzed the effect of offering a lower price during stockout to compensate for a customer's waiting time, using an EOQ-type inventory-modeling framework but solving simultaneously for both the optimal prices and the lengths of the in-stock and stockout periods.

The problem of deteriorating inventory has received considerable attention in recent years. This is a realistic trend since most products such as medicine, dairy products, chemicals, monitors and semiconductor start to deteriorate once they are produced. Most components of the 3C-product will lose original utility after a long time pass through. [9] were the first to authors to consider deterioration of epidemic product. [8] were the first authors to consider ongoing deterioration of inventory. They have developed an EOQ model for items with an exponentially decaying inventory. An exponentially deteriorating production-inventory model with permissible shortage was presented by [14]. [18] later studied an inventory model in which demand is price-dependent and inventory deteriorates at a varying rate, and proposed an algorithm for determining the maximum net profit.

In this study, deterioration is assumed to depend on the condition of the on-hand inventory within manufacturer and distributor. For the character of short product life cycle of the hi-tech products, the manufacturer tries to meet the distributor's request with one-time production, dynamic producing and multiple JIT deliveries to avoid idle time. For the selling price continuously decline in each player (manufacturer and distributor), the distributor reviews periodically the lot-size of replenishment and makes an EOQ ordering strategy. The selling price exponentially decreases over time till approaching its bottom. Meanwhile, the customer demand will linearly increases with the selling price down. This study proposes a heuristic approach to derive the near optimal replenishment policy that tries to maximize the manufacturer's profit and to an optimal product life cycle.

3. Notation and Assumptions

The mathematical model is developed on the basis of the following assumptions:

(1) Only a single-product item is considered.
(2) No shortage is allowed.
(3) There is no constraint in space, capacity or capital. Production rate can be changed.
(4) The lot-for-lot policy is used between manufacturer and distributor.
(5) The rate of replenishment in the distributor is instantaneous.
(6) A constant fraction the on-hand inventory deteriorates and no replacement of deteriorated items is allowed.
(7) The distributor's total cost associated with the inventory system consists of replenishment or ordering cost, holding cost and deterioration cost. All the cost coefficients are constant.

The following notation is used:

$I_i^S(t)$ The function of manufacturer's inventory level at time t during the i^{th} period

$I_i^B(t)$ The function of buy's inventory level at time t during the i^{th} period

$\rho_i^S(t)$ The unit selling (wholesale) price of manufacturer at time t during the i^{th} period, $\rho_i^S(t)=\rho_1\cdot e^{-\mu_S t}$

$\rho_i^B(t)$ The unit selling price of distributor at time t during the i^{th} period, $\rho_i^B(t)=\rho_1\cdot e^{-\mu_B t}$

ρ_i^S The unit selling (wholesale) price of manufacturer at the i^{th} period beginning

ρ_i^B The unit selling price of distributor at the i^{th} period beginning

U The distributor's producing cost per unit

H_S The holding cost per unit per unit time for manufacturer

H_B The holding cost per unit per unit time for distributor

D_S The deterioration cost per unit per unit time for manufacturer

D_B The deterioration cost per unit per unit time for distributor

O_S The setup cost per setup for manufacturer

O_B The order cost per order for distributor

μ_S The unit selling (wholesale) price decreasing rate for manufacturer ($\mu_S>\mu_B$)

μ_B The unit selling price decreasing rate for distributor ($\mu_S>\mu_B$)

q_i Numbers of order during the i^{th} period

p_i The production rate during the i^{th} period

t_i The i^{th} replenishment cycle time for distributor

$D(\rho_i^B(t))$ The demand function, $D(\rho_i^B(t))=A-B\cdot\rho_1\cdot e^{-\mu_B t}$

$D_i(\rho_i^B)$ The demand rate at time t during the i^{th} period

A The scale parameter of demand function

B The sensitive parameter of demand function

α Scale parameter of Weibull distribution ($\alpha>0$) of the deterioration rate

β Shape parameter of Weibull distribution ($\beta>0$) of the deterioration rate

υ The ratio of distributor share its profit. (When υ=1, distributor share all of profit to manufacturer.)

* The superscript representing optimal value

4. Mathematical model

We consider the supply chain inventory system consisting of multiple manufacturers, one distributor and multiple retailers as depicted in Figure 1. Their cost structures using integration strategy and independent strategy are developed as follows.

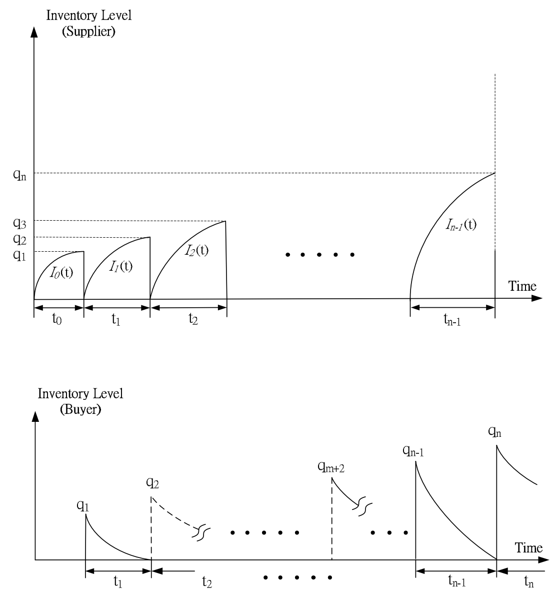

Figure 1. Inventory level of manufacturer and distributor.

4.1 Distributor Behavior

The lot-size of replenishment and selling price are reviewed periodically by the distributor at a sequence time t_i, i=1,2,3,..,n. At the beginning of each period, a decision is made regarding its associated selling price to decide the lot size q_i, which is delivered from the manufacturer. Within each period, the change in the distributor's inventory level during an infinitesimal time, dt, is a function of the deterioration rate, α and β, the demand rate, $D_i(\rho_i^B)$, and the inventory level of the replenishment period, $I_i^R(t)$.

We assume the demand rate, $D_i(\rho_i^B)$, is a linear function of the unit selling price, ρ_i^B. That is, $D(\rho_i^B)=A-B\cdot\rho_i^B$; "$A$" is the scale parameter, "B" is the sensitive parameter. It means that the customer demand will increase while ρ_i^B decreases. Furthermore, ρ_i^B is an exponentially decline function with time, t. That is, $d\rho_i^B(t)=-\rho_i^B(t)\cdot\mu_B\cdot dt$; "$\mu_B$" is distributor's decreasing rate of price. Then, we have $\rho_i^B(t)=\rho_1^B\cdot e^{-\mu_B t}$. The original distributor's selling price of the i^{th} replenishment period is $\rho_i^B=\rho_1^B e^{-\mu_B\sum_{k=2}^{i}t_{k-1}}$, $i=2,3,...,n$. Consequently, the demand rate of the i^{th} replenishment period is $D_i=D_i(\rho_i^B)=A-B\rho_i^B e^{-\mu_B t}$, $0\le t\le t_i$. The distributor's total inventory cost per unit time is depicted by the following formula: Total cost of profit = replenishment cost + holding cost + deteriorating cost. By computing the revenue, ordering (replenishment) cost, holding cost and deterioration cost (refer to Appendix I for the details), the distributor's total profit per unit time during each replenishing period can be expressed and derived as follows:

$$TP_i^B = \frac{SS_i^B - \left(OC + HC_i^B + DC_i^B\right)}{t_i}$$
$$= \left(\frac{1}{2\mu_B \cdot t_i}\right)\left(2A - B\rho_i^B\right)\left(1 - e^{-\mu_B \cdot t_i} + e^{-2\mu_B \cdot t_i}\right)$$
$$-\left(\frac{O_B}{t_i} + \left(\frac{H_B}{t_i} + \frac{\theta D_B}{t_i}\right)\left(\begin{array}{l}\left(A - B\rho_i^B\right)\left(\frac{t_i^2}{2} + \frac{\alpha\beta t_i^{\beta+2}}{(\beta+1)(\beta+2)}\right)\\ + \frac{B \cdot \mu_B \cdot \rho_i^B \cdot t_i^3}{3}\end{array}\right)\right) \quad (1)$$

4.2 Manufacturer Behavior

Figure 1 show that the manufacturer does not stop producing. Manufacturer's selling (wholesale) price, ρ_i^S , is an exponentially decline function with time, t as depicted in Figure 3. That is, $d\rho_i^S(t) = -\rho_i^S(t)\cdot\mu_S \cdot dt$; "$\mu_S$" is manufacturer's decreasing rate of price (wholesale). Then, we have $\rho_i^S(t) = \rho_1^S \cdot e^{-\mu_S t}$. The original manufacturer's selling (wholesale) price of the i^{th} replenishment period is $\rho_i^S = \rho_1^S e^{-\mu_S \sum_{k=2}^{i} t_{k-1}}$, $i = 2,3,\ldots,n-1$. The manufacturer's total inventory cost per unit time is depicted by the following formula: Total cost of manufacturer= setup cost + holding cost + deteriorating cost. By computing the revenue, the setup cost, the holding cost and the deterioration cost (refer to Appendix II for the details), the manufacturer's total profit per unit time during the production cycle can be obtained as:

$$TP_i^S = \frac{\left(SS_i^S - PC_i^S - HC_i^S - DC_i^S\right)}{t_n} \quad (2)$$
$$= \frac{\rho_{i+1}^S \cdot q_{n+1}}{t_i} - \frac{U \cdot q_{n+1}}{t_i} - \frac{(H_S + \theta D_S)}{t_i}\left(P_i\left(t_i^2 - \left(\frac{\alpha t_i^{\beta+1}}{\beta+1}\right)^2\right)\right)$$

5. Compensation policy

After n periods, manufacturer's profit decrease to very low and stop producing proposed, but distributor's profit is still increased. We propose a compensation policy to drive a globe optimal (a better solution). Our compensation policy depends on how many distributor want to share its profit, ν. $TP_i^{S'}$ is the manufacturer's total profit with compensation policy during the i^{th} period.

Maximize : $\sum_{i=0}^{n-1} TP_i^S + \sum_{i=n}^{m-1} TP_i^{S'}$ (3)

Subject to : $TP_i^{S'} = TP_i^S \cdot t_i + \nu \cdot TP_{i+1}^S \cdot t_{i+1}, i \geq n$ (4)

5.1 SIMULATED ANNEALING SOLUTION PROCEDURE WITH A GENETIC ALGORITHM

Using a direct analogy to this natural evolution, GA presumes a potential solution in the form of an individual that can be represented by strings of genes. Throughout the genetic evolution, beginning from a population of chromosomes, some fitter chromosomes tend to yield good quality offspring and moreover offspring inherit properties from their parents via reproduction, meanings better solutions to the problem can be obtained. Fig. 3 illustrates the evolution cycle of GA.

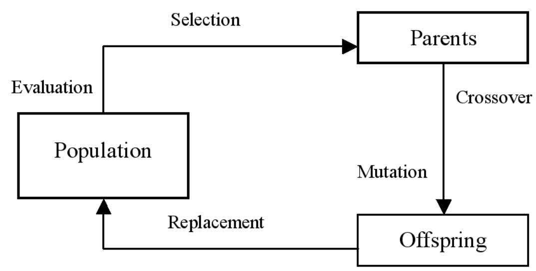

Figure 2. The evolutionary cycle of GA.

The decision variable is t_i (i=1,2,3,..,n). Genetic algorithms deal with a chromosome of the problem instead of decision variable. The values of T can be determined by the following genetic algorithm procedure:

Step 1. Representation: Chromosome encoding is the first problem that must be considered in applying GA to solve an optimization problem. Phenotype could represent an integer numbers here. For each chromosome, an integer number representation is used as follows:

x=(t_i)

Step 2. Initialization: Generate a random population of n chromosomes (which are suitable solutions for the problem)

Step 3. Evaluation: Assess the fitness f(x) of each chromosome x in the population. The fitness value $f_i = f(x_i) = ETC^*(x_i)$ where i =1,2,…,n.

Step 4. Selection schemes: Select two parent chromosomes from a population based on their fitness using a roulette wheel selection technique, thus ensuring high quality have a higher chance of becoming parents than low quality individuals.

Step 5. Crossover: Approximately 50%-75% crossover probability exists, indicating the probability that the parents will cross over to form new offspring. If no crossover occurs, the offspring are an exact copy of the parents.

Step 6. Mutation: About 0.5%-1% of population mutation rate mutate new offspring at each locus (position in the chromosome). Accordingly, the offspring might have genetic material information not inherited from either parent, thus avoiding falling into the local optimum.

Step 7. Replacement: An elitist strategy and a steady-state evolution are used to generate a new population, which can be used for an additional algorithm run.

Step 8. Termination: If the maximum generation exceeds the preset trial times, stop and return the best solution in current population; otherwise go to step 2.

6. Numerical example and discussion

The parameters are follows: $\rho_0^S = \$5$/unit, $\rho_1^B = \$10$/ unit, $U = \$4.5$/unit, $H_S =$ \$0.9/unit/year, $H_B =$ \$1.3/unit/year, $D_S =$ \$3.5/unit, $D_B =$ \$4/unit, $O_S =$ \$600/setup, $O_B =$ \$50/order, $\mu_S = 0.04$, $\mu_B = 0.02$, $A = 5000$, $B = 100$, α=0.15, β=1.5, $\nu = 0.05$.

Using the solution procedure stated in Section V, the optimal solution is derived as $\left\{n^*, \sum q_i^*, \sum t_i^*, TP_n^{B*}, TP_n^{S*}\right\}$ = { 29, 9,102.98, 2.3372, 85,661, 17,16 } without compensation policy. The product life cycle (PLC) is 2.3372 years. Demand, order amount, deterioration and inventory cost increase with time, period *i*. The manufacturer's selling price is also decreased with time and its decreasing is less than deterioration cost, so the distributor lengthens periods to maximize the profit. The detailed results are shown in Table 1.

In this case, distributor is the state of an absolute predominance; manufacturers must adjust its production planning according distributor's ordering and period time. By using the compensation policy, the optimal solution is derived as $\left\{n^*, \sum q_i^*, \sum t_i^*, TP_n^{B*}, TP_n^{S*}\right\}$ = { 32, 10,054.10, 2.5722, 94,008, 17,367 } . The product life cycle (PLC) is 2.5722 years. The product life cycle, total ordering, profit of distributor and manufacturer increase 10.05%, 10.45%, 11.73% and 1.20% respectively compared with the non-compensation policy. The detailed results are shown in Table 2.

7. Conclusions

This study has developed a deteriorating inventory model for products and selling price continuously decreasing. We proposed a replenishment policy for a distributor under a single-distributor-single-manufacturer partnership with one-time setup and dynamic producing of the manufacturer and multiple JIT deliveries of the distributor using EOQ ordering strategy. Compensation policy can extend product life cycle and make more profit both of manufacturer and buy. Our proposed model and policy can maximize the manufacturer's profit during a finite planning horizon and then to derive an optimal product life cycle.

Numeric examples and sensitivity analyses indicate some very interesting properties. When the distributor intelligently applies JIT and EOQ ordering policy, the whole supply chain earns profits, while if the distributor is self-centered to ask for reduction on the manufacturer's wholesale price and distributor's holding cost, the whole system suffers. Manufacturer should try to reduce producing cost because it is very useful to supply chain. We conclude that if the supply chain partners collaborate together and sometime compensation is needed to improve individual as well as system profits. Other market parameters are examined as well in the study.

The future research can apply dynamic producing to production planning. At last, our model has potential application in a three-echelon (add a distributor) or multi-echelon (multiple manufacturers, multiple distributors, multiple distributors) supply chain inventory system.

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References

[1] Aggarwal, S.C., 1981. Purchase-inventory decision models for inflationary condition, *Interfaces*, **11**, 18-23.

[2] Banerjee, A., 1985. A joint economic lot size model for purchaser and vendor. *Decision Science*, 17, 292-311.

[3] Bhargava, H.K., Sun, D., Xu, S.H., 2006. Stockout compensation: Joint inventory and price optimization in electronic retailing, *INFORMS Journal on Computing*, **18**, 255-266.

[4] Coughlan, A.T., Anderson, E., Stern, L.W. and EI-Ansary, A.I., 2001. *Marketing Channels*, 6th ed. Upper Saddle River, NJ: Prentice Hall.

[5] Donaldson, W.A., 1977. Inventory Replenishment Policy for A Linear Trend In Demand – An analytical Solution, *Journal of the Operational Research Society*, **28**, 663-670.

[6] Eilon, S., and Mallaya, R.V., 1966. Issuing and pricing policy of semi-perishables, Proceedings of the 4th International Conference on Operational Research, New York, Wiley-Interscience.

[7] Goyal, S.K., 1977. Determination of optimum production quantity for a two-stage production system. *Operational Research Quarterly*, 28, 865-870.

[8] Ghare, P. M. and Schrader, S. F., 1963. A model for an exponentially decaying inventory. *Journal of Industrial Engineering*, **14,** 238-243.

[9] Hadley, G., and Whitin, T.M., 1961. An Optimal Final Inventory Model, *Management Science*, **7**, 179-183.
[10] Hadley, G., 1964. A comparison of order quantities computed using the average annual cost and discounted cost, *Management Science*, **10,** 472-476.
[11] Harris, F.W., 1913. How many parts to make at once. Factory. *The magazine of Management*; **10** (2), 135-52.
[12] Katler, P., 2003. *Marketing Management*. 11th ed. Upper Saddle River, NJ: Prentice Hall.
[13] Kelle, P., Al-Khateeb, F., Miller, P.A., 2003. Partnership and negotiation support by joint optimal ordering/setup policies for JIT, *International Journal of Production Economics*, 431-441.
[14] Raafat, F., Wolfe, P. M. and Eldin, H. K., 1991. An inventory model for deteriorating items. *Computers & Industrial Engineering*, **20**, 89–94.
[15] Sarker, Bhaba, R., Jamal, A.M.M., AND WANG, SHAOJUN, 2000. Supply chain models for perishable products under inflation and permissible delay in payment, *Computers & Operations Research*, **27**, 59-75.
[16] Silver, E.A., 1979. A simple inventory replenishment decision rule for a linear trend in demand, *Journal of The Operational Research Society*, **30**, 71-75.
[17] Wee, H.M., 1995. Joint pricing and replenishment policy for deteriorating inventory with declining market. *International Journal of Production Economics*, 40, 163-171.
[18] Wee, H.M., 1997. A replenishment policy for items with a price dependent demand and a varying rate of deterioration. *Production Planning and Control*, **8**, 494–499.
[19] Wee, H.M. and Law, S.T., 2001. Replenishment and pricing policy for deteriorating items taking into account the time-value of money. *International Journal of Production Economics*, **71**, 213–220.
[20] Yang, P. C. and Wee, H. M., 2001. A quick response production strategy to market demand, *Production Planning Control*, **12**, 326-334.

Table 1. The numerical results for illustrated example without compensation policy

Period (i)	t_i	$\sum_{k=1}^{i} q_k$	$\sum_{k=1}^{i} TP_k^B$	p_i	TP_i^S	$\sum_{k=1}^{i} TP_k^S$
0	0.0750	N/A	N/A	4156.23	-6218	-6218
1	0.0777	311.14	2930	4014.79	1649	-4569
2	0.0778	622.48	5862	4012.22	1588	-2981
3	0.0778	934.02	8795	4014.67	1526	-1455
4	0.0778	1245.75	11730	4017.25	1465	11
5	0.0778	1557.68	14667	4019.82	1404	1415
6	0.0778	1869.81	17606	4022.27	1343	2758
7	0.0779	2182.13	20546	4019.69	1283	4041
8	0.0779	2494.65	23488	4022.27	1222	5263
9	0.0779	2807.36	26432	4024.71	1161	6424
10	0.0779	3120.28	29377	4027.28	1101	7525
11	0.0779	3433.39	32324	4029.85	1041	8566
12	0.0780	3746.69	35273	4027.14	981	9547
13	0.0780	4060.20	38223	4029.71	921	10467
14	0.0780	4373.90	41176	4032.28	861	11328
15	0.0780	4687.79	44129	4034.72	801	12129
16	0.0780	5001.89	47085	4037.29	741	12870
17	0.0781	5316.18	50042	4034.7	682	13552
18	0.0781	5630.66	53001	4037.14	622	14175
19	0.0781	5945.35	55962	4039.71	563	14738
20	0.0781	6260.23	58924	4042.27	504	15242
21	0.0781	6575.30	61888	4044.71	445	15687
22	0.0781	6890.57	64854	4047.28	386	16073
23	0.0782	7206.04	67822	4044.68	327	16401
24	0.0782	7521.71	70791	4047.11	269	16670
25	0.0782	7837.57	73761	4049.68	210	16880
26	0.0782	8153.63	76734	4052.11	152	17032
27	0.0782	8469.88	79708	4054.67	94	17126
28	0.0783	8786.33	82684	4052.07	36	17161
29	0.0783	9102.98	85661	N/A	N/A	N/A

Table 2. The Numerical Results For Illustrated Example With Compensation Policy

Period (i)	t_i	$\sum_{k=1}^{i} q_k$	$\sum_{k=1}^{i} TP_k^B$	p_i	TP_i^S	$\sum_{k=1}^{i} TP_k^S$
0	0.0750	N/A	N/A	4156.23	-6218	-6218
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25	0.0782	7837.57	73761	4049.68	210	16880
26	0.0782	8153.63	76734	4052.11	152	17032
27	0.0782	8469.88	79708	4054.67	94	17126
28	0.0783	8786.33	82684	4052.07	36	17161
29	0.0783	9102.98	85512	4054.5	126	17288
30	0.0783	9419.82	88343	4057.06	69	17356
31	0.0783	9736.86	91174	4059.62	11	17367
32	0.0783	10054.1	94,008	N/A	N/A	N/A