Pricing and Determining the Optimal Discount of Perishable Goods to Speed up Demand Rate

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Abstract: In the competitive market of perishable cargoes, determining the price of the product and making opportunities for customers to accelerate the sale of goods through discounts is crucial. Over the life of perishable goods, generally its value reduced to the customer, in this situation, to encourage the purchase, policies such as a discount or reduced price sales policies can be effective. Literature has not provided a model for determining the optimal time to announce a price reduction. While early or late prices announcement could reduce profit, the aim of this paper is to analyze such a model at the level of an enterprise. In the modeling, we assumed that by announcing price discount, tangible changes occur in demand, and demand is a function of price and time. The demand rate in the discount time is decreasing in the beginning of the time and then declining over time. The purpose of the model is determining the optimal price, discount time and order size to maximize the total profit in a single period. After modeling, concavity of the profit function is considered and optimal pricing and discounts are exclusive. Then, a heuristic algorithm derived from the literature was used in order to determine the optimal price, the optimal discount time and the optimal order quantity.

Keywords: Pricing, Perishable product, Price discount

Introduction: In this article, the term "perishable" is used for goods that, due to rapid technological changes or the introduction of new products by competitors, should lose their value over a period of time. For example, fashion goods in the season will quickly fall in price, because otherwise the need for spare parts for military aircraft is one of fashion goods that would be unusable if a new aircraft model is being used (Khanlarzadeh et al., 2014). When non-perishable products approach their expiration date, they often use price discounts. Tajbakhsh et al (2011) developed an inventory model at a price of Random Discount, and numerical analysis that showed cost saving through discounts. The research conducted in the field of pricing and bidding for the aforementioned commodities, only several models have been developed that are either definitive or random models with known distributions (Wang, 2012). Rajan et al. (1992) have developed pricing policies and ordered for definitive applications. Also, if problem modeling occurs in the supply chain, competition between the members of the chain is formed to generate more profit. Zhang et al. (2015) considered a supply chain model with a producer and retailer for degraded items at a time-rate and price-dependent demand. They have designed an algorithm for obtaining price and investment protection technology strategies, and have examined both centralized and decentralized scenarios. In this article, the pricing of a perishable goods is considered under discounted conditions, and given the importance of selling these products over the life of the customer, it is essential to pursue a policy that can encourage customers to buy more. Also, the discount policy comes with the synchronization of the demand function during the discount period. In the absence of discounts, the demand rate is a function of the time and price, and in the discount period, the demand function is initially at an incremental time, and after the discount, the time is reduced. In the literature examined, the price for the final customer, which affects demand and does not change the demand for demand function, is not taken into account. For example, Meihami and Karimi (2014) show a change in demand after advertising with a coefficient in the demand function has given. While in the real world, with the announcement of a discount, the function of the rate of demand for perishable goods varies and is not mentioned in any of the previous investigations. In the following, we describe the assumptions and symbolization of problem modeling.

Materials and Methods:
It is assumed that the maximum inventory in the first period (I_0) is the order quantity, and its decreasing is only affected by demand. As a price mark-down should always be applied before the expiration date of the product, the time horizon for product selling can be divided into two intervals: [0, t] and [t,T].
Notice that due to the discount after the price mark-down, the demand rate function during the time intervals [0, t] and [t, T] is different, in the interval [t, T], the product is sold out at the discount price $p(1-\alpha)$. Due to the discount, a moderate growth in the demand initially occurs; however, it reduces gradually (see Fig. 1.).
There is no shortage, nor surplus in the end of the time horizon, i.e., period T, so the inventory level is the demand in that period. On the other hand, the demand in the time interval [0,t] can be expressed as follows,

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$$ED_t = \int_0^t D(p,t)\,dt = \int_0^t (a-bp)e^{-\lambda t}\,dt = \frac{(a-bp)}{\lambda}[1-e^{-\lambda t}], \quad (1)$$

and the profit can be expressed,

$$TP = (p-c)\int_0^t D(p,t)dt + (p(1-\alpha)-c)\int_t^T D(p,t)dt$$
$$= (p-c)\left[\frac{(a-bp)}{\lambda}(1-e^{-\lambda t})\right] + (p(1-\alpha)-c)\left[\frac{1}{\lambda^4}(a-bp(1-\alpha))(e^{-t\lambda}(6+t\lambda(6+t\lambda(3+t\lambda))) + e^{-T\lambda}(-6-T\lambda(6+T\lambda(3+T\lambda))))\right]). \quad (2)$$

The methodology must be clearly stated and described in sufficient detail or with sufficient references containing the research model and tools.

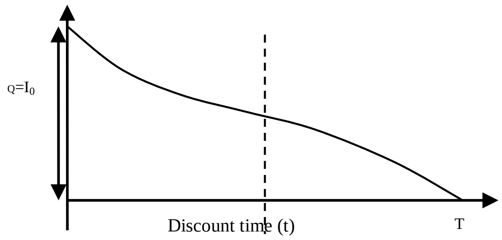

Fig. 1. Inventory level in period T

Results and Discussion: The proposed algorithm is used for solving the following numerical example to illustrate the solution process and results. Mathematica 9 was used in this regard.
Example. The following parameters and functions are used.
$D_1(p,t) = (500-0.5p)e^{-0.98t}$, $D_2(p,t) = (500-0.5p)t^3e^{-0.98t}$ T=2, c=200, α=0.3
Table 1 show, the convergence of the algorithm, where for the quasi-optimal tolerance ε, it results in p*=694.826 , t*=1.008, TP*=104558.612, Q*=293.945, and the numerical results are obtained for the price interval [400, 1000].

Table 1- Computational results of Example 1.

k	p_k	t_k	TP_k
1	600.000	1.078	100182.512
2	690.310	1.012	104548.806
3	694.597	1.008	104558.573
4	694.813	1.008	104558.611
5	694.825	1.008	104558.612
6	694.826	1.008	104558.612

Conclusion: In this paper, the pricing model for non-perishable goods was presented under discounted sales terms. In modeling the hypothesis problem by declaring a decline in sales prices, the demand rate has a tangible change, and demand is a function of price and time. In this paper, it was proved that the goal of profit is optimal and unique in terms of optimal price and discount time. With using a simple algorithm, a numerical example of a model and results are analyzed using sensitivity analysis on model parameters. The model presented in this paper is a comprehensive and complete model, and compares to different values of the parameters of the flexible demand function. The model presented in this study can be expanded in several ways; the demand rate in this paper is definite. It is considered to be time-dependent, with its probability, it is possible to define a suitable topic for future research. We can also consider the discount percentage variable. On the other hand, advertising policies, delay in payments and coordination models in the supply chain system and reviewing the results can be considered.

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