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An incorporated inventory transport system with two types of customers for multiple perishable goods

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ABSTRACT

Perishable goods comprehend a large space daily marketing of goods. These kinds of goods ask a strict inventory control. Due to fast movement of these goods from distributer to retailer, it is necessary to have a command over the transportation system to maximize the profit. In this research, the transportation model has been mapped with the inventory model with time varying demand and two types of customers for different perishable goods to simultaneously maximize the revenue and minimize transportation and inventory cost, and hence maximizing the net profit. The model assumes fixed shortage, handling and outdating cost and selling price of goods decreases with time. An illustrative example is provided at the end to reveal the application of proposed methodology on a given system. Insight gained would be of much interest to the distributers of perishable goods in managing the inventory and transportation for same.

1. Introduction

The minimization of the supply-chain inventory and transportation cost has been the premier area of researchers since long. Many literatures can be found out in the same field considering different real world situations. In the literature several models are presented in which it is assumed that the product can be stored in the inventory for infinite time to meet the future demand and there are infinite numbers of vehicles available for transportation of goods. However in reality, many items cannot remain in inventory for infinite time, they are perishable in nature. Perishability refers to the property of an item to deteriorate after a particular period of time, which is a consequence of variations in demand and speculative ordering policies. Fruits, vegetables, meat, foodstuffs, perfumes, alcohol, gasoline, photographic films, etc., are some examples where deterioration may typically occur during their normal storage period. Stashing of perishable item is a complicated task. If the deterioration rate of the product is significant, its impact on inventory transport system cannot be ignored (Zanoni and Zavanella, 2007). If the fluctuation in demand is high then it becomes more difficult to handle the inventory of perishable goods, because there will be a large amount of outdating of the goods. Inventory and transportation of perishable goods is now becoming a field of prime interest of researchers.

As stated by Zanoni and Zavanella (2007), perishable goods can be divided into two sub-groups:

I. ***products with fixed life span***, when products maintain their usefulness for a fixed period of time and then must be deemed useless; and
II. ***products with a variable life span***, if their usefulness diminishes over time, according to the product age.

Various literatures can be found out in the field of inventory and transportation of perishable goods with a fixed life span, however a little has been done for the variable life time. For perishable goods having a variable life time, its usefulness diminishes over time and consequently its cost reduces with usefulness.

This paper uses the model proposed by Ishii (1993). However the model in the referred research is simple and deals with only inventory and shortage cost and profit functions for a single perishable item with variable life span whose cost decreases with time. The model assumes there are two types of customers one who buys only fresh goods and demand due to these kinds of customers it has been called as *high priority demand*, and the second type of customer who buys both fresh and old goods but with relaxations in price and this demand has been called as *low priority demand*. The model has been extended in this research by integrating transportation model with the referred model for multiple perishable items (Fig. 1). The transportation model proposed is a limited capacity transportation model having variable cost in accordance with the type of carrier used for transportation. The excess quantity is assumed to be transported by calling external service provider at cost higher than self transport system.

The overall approach of this research and relation between different models i.e. the initial model, the transportation model and the integrated model has been briefly portrayed in Fig. 2.

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The remainder of this paper is structured as follows: Section 2 consists of theoretical background and relevant research in this area. Section 3 deals with model formulation for different costs and revenue associated with inventory and transportation of perishable goods. An illustrative example has been worked out in Section 4 where demand for 5 different perishable goods is considered and optimal number and capacity of vehicles has been reckoned. Lastly, the conclusion and recommendations for future work is portrayed in Section 5.

2. Theoretical background

Plenty of research work can be found out in field of ordering and storage of perishable goods. The first work on perishability is attributable to Ghare and Schrader (1963). The authors pointed out that inventory decay could exert a significant impact on the overall inventory costs, while considerable cost savings could be achieved if the inventory analysis took the inventory decay into consideration. Ishii et al. (1981) proposed a new model for inventory and ordering of perishable goods with stochastic lead time. They considered zero or 1 unit lead time and derived the optimal ordering policy for one period horizon. Nose et al. (1984) generalized the model with perishable products and stochastic lead time. They estimated various parameters in the model and finally concluded with the optimal ordering policy in accordance with the time varying demand and varying lead time. Ishii (1993) proposed an inventory control model with two types of customers with different selling price for a single perishable good. This model was a one period horizon model and was generalization of Nose et al. (1984). Later on Ishii and Nose (1996) extended this model by adding ware house capacity constraint and observed profit within different cases regarding quantity remaining in inventory. Katagiri and Ishii (2002) extended same model by incorporating fuzzy shortage and outdating costs.

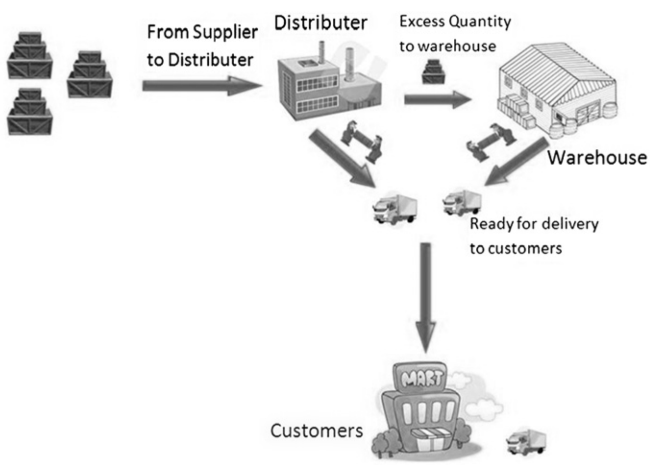

Fig. 1. The proposed inventory-transportation model.

Speranza and Ukovich (1994) determined the frequencies at which several products have to be shipped on a common link to minimize the sum of transportation and inventory costs. They assumed that the transportation costs are proportional to the number of journeys performed by vehicles of a given capacity. They evidenced allowing products to be split among several shipping frequencies makes trucks traveling at high frequencies to be filled up completely. Chiu (1995a) proposed a continuous review inventory model based on approximations to the expected outdating, the expected shortage quantity and developed the expected inventory level to determine the best (Q, r) ordering policy under a positive order lead time when the total expected average cost per unit time is minimized. Chiu's (1995b) heuristic (R, T) periodic review model considering the expected outdating and the total expected costs of holding inventory, ordering, backlogging unsatisfied demand, and disposing of perished inventory.

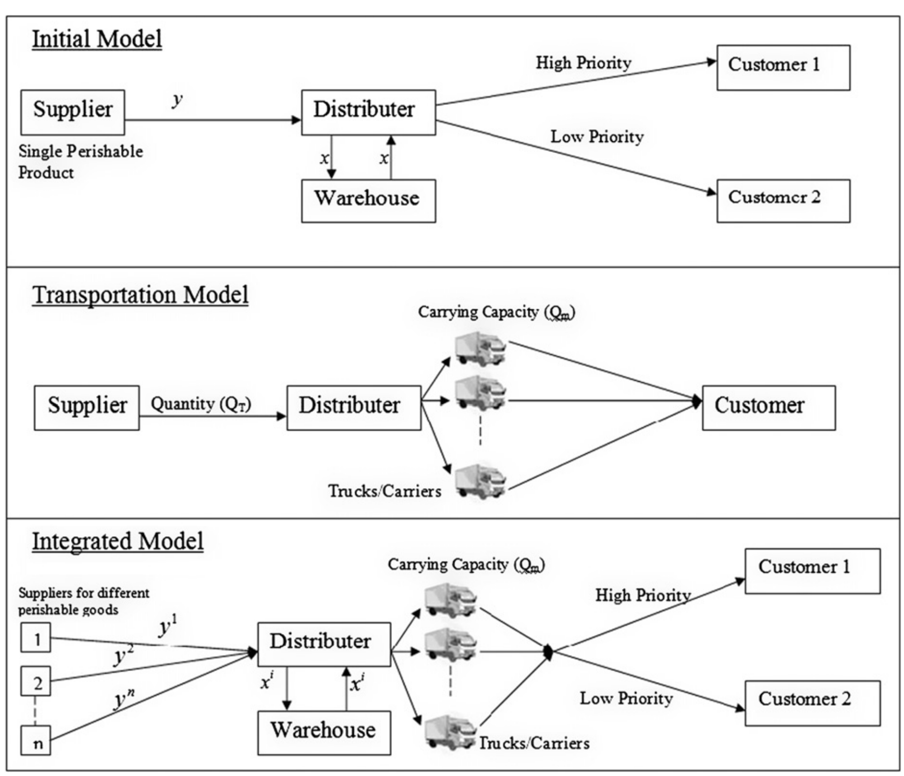

Fig. 2. Relationship between different models.