Applied Mathematics and Computation 256 (2015) 913–929

Contents lists available at ScienceDirect

Applied Mathematics and Computation

journal homepage: www.elsevier.com/locate/amc

Pricing and replenishment policies in dual-channel supply chain under continuous unit cost decrease

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ARTICLE INFO

Keywords:
Dual-channel
Unit cost decrease
Replenishment policy
Coordination

ABSTRACT

This paper explores pricing and replenishment policies for a high-tech product in a dual-channel supply chain that consists of a brick-and-mortar channel and an internet channel. The unit cost of the product decreases over its short life cycle. Assuming the manufacturer as the Stackelberg leader, the optimal pricing and replenishment policy is *analysed mathematically*. It is found that there is a severe price competition between the retail and online channel, and product compatibility has a significant impact on the pricing policy. In particular (i) customers' higher retail channel preference above a threshold leads to non-coexistence of dual-channel, (ii) the dual-channel is non-profitable for product compatibility outside an interval and (iii) higher or lower retail price in comparison to online price is dependent on product compatibility. Also, the retailer's higher setup cost may lead to non-existence of online channel. Finally, a profit sharing mechanism through wholesale price adjustment resolves channel conflict. A numerical example is *illustrated to justify our proposed model.*

1. Introduction

The rapid growth of internet based electronic commerce has attracted the manufacturers of several companies such as, IBM, HP, Sony, Kodak, Panasonic, Cisco, etc to introduce direct online channels to their existing brick-and-mortar retail networks. Reduced cost for searching, increasing contact with the customers and detail specification and information of the products through the internet enable the manufacturer to enhance it's market coverage. The growth of US online marketing is forecasted at 8% in 2010 and is set to reach 14% by 2012. Two third (2/3) of the marketers believe that online business must be complemented by traditional marketing activities [1]. As a result, manufacturers redesign their traditional channel structures by engaging in direct sales to reach different customer's segments that cannot be reached by the traditional retail channel. This channel structure births to the dual channel. In fact, manufacturers who sell only through retailers are now considering the option of selling directly to end customers. Since, in dual-channel of same/substitutable product is sold through retail store as well as online channel. *Consequently, the* customers have alternatives to choose the channel that is better suited for their needs [2].

Decreasing *property of price component* and diminishing of demand over time due to introduction of upgraded versions of components are now important characteristics of high-tech industrial market. In high-tech industries such as communication

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http://dx.doi.org/10.1016/j.amc.2015.01.081
0096-3003/

and computers, some component cost is *decreasing around* one percent per week [3]. Thus, production and sale *in* one week earlier or later leads to about 1% loss or gain. As a matter of fact, in decreasing unit cost environment, the decision maker always remains in searching the appropriate selling price because it has a considerable impact on demand *as well as on optimal ordering policy*. Thus, optimal pricing strategy [4–12] is a major issue to attract the customers in any business organization in a given economy.

Various aspects of dual-channel supply chain, such as advantages and disadvantages of online channel in addition to brick-and-mortar channel, when to open an online channel, pricing policies, replenishment policies, price competition, retail services, sales effort in retail channel, return policies, etc have been explored extensively in supply chain literature. Interestingly, there is no research till date that has discussed pricing and replenishment policies for the hi-tech products, whose unit costs decrease continuously in their short life span. Hi-tech products have high online compatibility and tech savvy customers that generally considers the specifications of the products through online channels and compare the retail prices with the products in online manufacturers' suggested retail prices. In such situation there is a need for the manufacturer to identify online price and replenishment/production policy of a product that reduces total channel cost *effectively that* increases channel profit.

In inventory literature, there are a few models concerning continuous cost changing. Both Buzacott [13] and Erel [14] have proposed two inventory models where the unit cost of the product increases under inflationary situation. Erel [14] has developed the model under the assumption that the unit cost of the product increases in compound nature. Whereas, Buzacott [13] has assumed compound increments of both unit cost and setup cost. Goyal et al. [15] have developed inventory models under decreasing feature of unit cost. Khouja and Goyal [16] have suggested that the model of Buzacott [13] can be used for continuous unit cost change, if the rate of change of unit cost is same as the ordering cost. Erel's [14] model is also applicable in this purpose. But, if the rate of inflation is less than 10%, then the models provide wrong approximation. Teng and Yang [17] and Teng et al.[18] have developed inventory models under partial backlogging where demand and cost fluctuate over time. In both the models, optimal replenishment policy and optimal purchasing policy have been determined to minimize system running cost. They have claimed that this policy fits for todays high-tech market. Khouja and Goyal's [16] model may be considered as a special case of Teng and Yang [17] and Teng et al. [18] with constant demand and unit cost dependent holding cost. *In unit cost decrement inventory literature*, interested readers may consult the paper of Khouja and Park [19] which provides interesting review of the literature associating it with the existing industrial scenario. Khouja and Park [19] have developed an inventory model to determine optimal operating policy in which the unit cost of the product decreases continuously by a constant percentage. Under the restriction of equal cycle lengths for finite time horizon, they have derived an approximate close form value for the optimal cycle length to minimize system operating cost. Panda [20] has determined the optimal pricing and replenishment policy in a *decreasing demand with time* and price sensitive market where the unit cost of the product decreases linearly with time. *Cardenas-Barron et al.* [21] *have* suggested a heuristic algorithm to solve the vendor management inventory system with multi-product and multi-constraint based *EOQ model* with backorders,considering two classical backorders costs: linear and fixed. Sarkar and Majumder [22] *have* investigated an integrated vendor–buyer supply chain model to reduce total cost of the channel by considering the setup cost reduction of the vendor.

As indicated above, in addition to traditional brick-and-mortar channel, a new channel *provided to the customers directly* through internet is *prevailing* in practice because of it's intuitive advantages. As a result, dual-channel supply chain has got enormous attention and *become* in main stream. Extensive researches have been done addressing variety of problems in dual-channel supply chain. For example, Levary and Mathieu [23] have examined the profits of retail store, online store and dual-channel, and have concluded that the dual-channel provides maximum profit. Ahn et al.[24] have discussed about the pricing decisions of a dual-channel supply chain, where the retail channel and the online channel operate in spatially separated markets. Huang et al. [25] have determined the optimal pricing strategies in a retail-e-tail supply chain by considering price dependent demand, a degree of substitution across the channel and the over all market potential. Yan [26] has developed a dual-channel supply chain *incorporating* differentiated branding strategy. He has concluded that *it does not resolve full channel conflict although differentiated branding strategy alleviates channel competition and conflict.* Dan et al. [1] have determined optimal retail service and prices in centralized and de-centralized dual-channel supply chain. Chen et al. [27] have *proposed* the manufacturer's pricing strategies in a dual-channel supply chain. They have also *showed* that the channel conflict can be resolved by applying two-part tariff or a price sharing agreement. In this direction, the works of Saha [28], Hua et al. [29], Qi et al. [30], Xing et al. [31], Ma et al. [32] are worth mentioning.

Coordination among the channel members has potentiality to realize the benefits of the members *of the chain.* To coordinate *the members of a supply chain*, contracts are designed *effectively* among the decentralized decision makers such that the difference between outcome of a centralized decision and decentralized decisions can be neutralized. The basic objective behind designing a coordination contract is to incentivize decentralized channel members to act coherently with one another. Variety of side-payment contracts *like as* quantity discount [30,33], quantity flexibility [31,34], two-part tariff [35], revenue sharing [36,37], sales rebate [38], buy back [39], credit option [40], mail-in-rebate [41], disposal cost sharing [42,43] *etc.,* have been used in supply chains as the ways of cutting out of channel conflict. These contracts differ by contractual clauses among channel members and are primarily concerned with quantity, time, quality and price. For detail discussion on channel coordination, the survey papers of Cachon [44] and Sarmah et al. [45] are referred to the readers.

Although supply chain literature has rich content on two-echelon supply chain coordination, there are few papers which *are dealt* with resolving channel conflict in a dual-channel supply chain. Cai [46] has showed that hybrid revenue