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Wholesale price rebate vs. capacity expansion: The optimal strategy for seasonal products in a supply chain

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ABSTRACT

We consider a supply chain in which one manufacturer sells a seasonal product to the end market through a retailer. Faced with uncertain market demand and limited capacity, the manufacturer can maximize its profits by adopting one of two strategies, namely, wholesale price rebate or capacity expansion. In the former, the manufacturer provides the retailer with a discount for accepting early delivery in an earlier period. In the latter, the production capacity of the manufacturer in the second period can be raised so that production is delayed until in the period close to the selling season to avoid holding costs. Our research shows that the best strategy for the manufacturer is determined by three driving forces: the unit cost of holding inventory for the manufacturer, the unit cost of holding inventory for the retailer, and the unit cost of capacity expansion. When the single period capacity is low, adopting the capacity expansion strategy dominates as both parties can improve their profits compared to the wholesale price rebate strategy. When the single period capacity is high, on the other hand, the equilibrium outcome is the wholesale price rebate strategy.

1. Introduction

In a supply chain, manufacturers and retailers always seek to match supply with demand through production planning and demand management. For seasonal products, in particular, members of the supply chain need better strategies for coordinating supply and demand. For example, air conditioner manufacturers that face high demand during the summer may not fully respond to orders from their downstream partners because of a significantly long leadtime of production. Hence, manufacturers generally shift a proportion of their production to earlier periods and store produced goods in the warehouse to satisfy peak-season demand. This production movement indirectly heaps inventory holding pressure onto the manufacturers. A similar phenomenon also occurs within the fashion apparel industry in which retailers usually place a single order with their manufacturers because of offshore production, making replenishment difficult to arrange. Faced with these situations, manufacturers may adopt a variety of strategies to alleviate the pressure of product shortage and to foster supply chain efficiency.

To mitigate the risk of production shortage, manufacturers can initiate production at earlier periods and encourage retailers to hold these items. In pursuit of this goal, an incentive should be offered to the retailers to compensate for the costs of storing these items. One commonly used strategy is the wholesale price rebate. A notable example dates back to 1994 when Gree, China's largest air conditioner manufacturer, faced a situation where almost all the retailers ordered items close to the peak season. To tackle this issue, Gree came up with a new pricing policy, the off-peak season rebate. To wit, if the retailer was willing to take delivery of the air conditioners during the off-peak season, Gree provided a price discount. This strategy successfully filled the spare capacity of Gree's production in the off-peak season and reduced the possibility of product shortage in the peak season.

Another strategy manufacturers may adopt in response to peak season demand is to use a temporary workforce or equipment or to implement workforce overtime to increase capacity. Practical applications of this strategy are widely observed in both manufacturing and service industries, such as automobile and tourism sectors (Chopra and Meindl, 2009). These examples identify an intrinsic rationale through which the manufacturers or service providers adjust their capacity during the peak season to further avoid shortage loss. Although the capacity expansion is an additional expense for manufacturers, aggregating production close to the peak season not only reduces setup costs, but also increases the flexibility of matching demand orders.

In this paper, we consider a two-echelon supply chain in which a manufacturer sells a seasonal product to the end market through

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a retailer. On one hand, the retailer faces a fully competitive market wherein the retail price is exogenously determined and the only decision the retailer can make is the order quantity. The manufacturer, on the other hand, is able to allocate production across two time periods. To mitigate the pressure of holding inventories, the manufacturer should postpone the production to the period close to the selling season and set up the production line in an earlier period only if the order exceeds the capacity of a single period, which is called *basic strategy*. In addition, we further investigate two strategies of the manufacturer:

- *Wholesale price rebate strategy*: the manufacturer offers subsidies to the retailer for taking delivery in the earlier period.
- *Capacity expansion strategy*: the production capacity of the manufacturer is expanded in the second period.

We characterize the optimal decisions of the manufacturer and the retailer in each strategy and compare the profits of both parties to a situation where the basic strategy is adopted. To gain additional managerial insights, we assume the market demand follows a uniform distribution, and conditions are provided to obtain the manufacturer's preferred strategy. Our results reveal that when single period capacity is sufficiently high, the manufacturer tends to adopt the wholesale price rebate strategy and associated order quantity of the retailer is also larger under the strategy. This is due to the fact that under the wholesale price rebate strategy, the manufacturer raises the wholesale price charged to the retailer to a high level and the retailer gains more profits when the order quantity exceeds the single period capacity. This high wholesale price decision combined with a rebate to the retailer leads to a high order quantity accordingly. This effect diminishes as the single period capacity is low and in this case the equilibrium outcome moves to the capacity expansion strategy. Also, our numerical study shows that among the three strategies, both parties are better off by implementing the capacity expansion strategy compared to the basic strategy. On the other hand, the manufacturer can improve its profit under the wholesale price rebate strategy but the retailer is worse off even though a compensation is offered by the manufacturer under this strategy.

The remainder of this paper is organized as follows. Section 2 provides a survey of relevant literature. Sections 3 and 4 describe our models and derive analytical results, respectively. In Sections 5 and 6, we demonstrate the results when the demand follows a specific distribution and implement the numerical study. A discussion of the results is included in Section 7. All proofs are relegated to Appendix A.

2. Literature review

We review the literature with regard to three aspects: seasonal products, supply chain contracts, and capacity management. Two distinct characteristics of the seasonal products, namely, cyclical demand and perishability, give rise to many interesting research topics in production planning. An earlier research that investigates seasonal products can be traced back to Chang and Fyffe (1971). Voros (1999) discusses the risks faced by manufacturers who produce seasonal goods and provides suggestions on minimizing risks by a learning effect on the uncertain demand. Chen and Xu (2001) conclude that downstream members in a supply chain, such as retailers, tend to issue demand orders for seasonal products as close to the selling season as possible.

In the traditional supply chain, seasonal products generally have a relatively low salvage value at the end of the selling season. One of the major factors affecting the number of unsold items is the retail price. Smith and Achabal (1998) conclude that clearance price at the end of the selling season and inventory management significantly influence a retailer's profits. Furthermore, Bitran and Mondschein (1997) consider the seasonal product as non-refundable. Thus, retailers lower retail prices to promote sales at the end of the selling season. In addition, Aviv and Pazgal (2008) consider the existence of strategic customers and adopt the Stackelberg game to obtain the optimal pricing strategy. DeYong and Cattani (2012) use a two-period newsvendor model for a case where an order quantity can be revised based on updated information.

Our research is also related to the topic of supply chain contracts in a decentralized supply chain. Bresnahan and Reiss (1985) investigate the relationship between the marginal revenue of a car dealer and the pricing model of a manufacturer. Lariviere and Porteus (2001) discuss the wholesale price decision for a manufacturer in a newsvendor setting. Padmanabhan and Png (1997) compare the profits of a manufacturer among different scenarios depending on whether the manufacturer allows the return of unsold items. Cachon and Zipkin (1999) study the effect of providing subsidies to the retailer, and Viswanathan and Wang (2003) study the effect of price elasticity on quantity discount. Marvel and Peck (1995) consider a scenario with uncertain demand where the manufacturer changes the return policy for the retailer. Cachon (2002) summarizes several contracts designed by a manufacturer to enhance profit and investigates whether the manufacturer can provide some incentives to the retailers so as to coordinate the supply chain. These widely used contracts include buyback contract (Emmons and Gilbert, 1998), revenue sharing contract (Cachon and Lariviere, 2005; Dana and Spier, 2001; Giannoccaro and Pontrandolfo, 2004), sales rebate contract (Taylor, 2002) and quantity flexibility contract (Lian and Deshmukh, 2009; Tsay, 1999; Tsay and Lovejoy, 1999).

A fair amount of research explores capacity management in a supply chain. Clearly, proper capacity planning and management can reduce costs, satisfy orders on time, lower inventory level, raise utilization of equipment, and alleviate the fluctuation of throughput and labor usage (Chase, 2006). For seasonal products with cyclical demands, the manufacturer has to determine the optimal capacity and inventory level to reduce shortage and inventory costs (Bradley and Arntzen, 1999). Metters (1997) develops a heuristic algorithm for a multiple-period production problem with stochastic seasonal demand and limited capacity. Metters (1998) also summarizes several principles for the manufacturer when producing seasonal products. Aviv and Federgruen (2001) investigate the trade-off between the investment of capacity and service level under the fluctuation of seasonal demand. Mathur and Shah (2008) study a case in which the manufacturer designs a contract with two-way penalties for coordinating supply and demand.

3. Model description

We consider a supply chain in which a manufacturer sells a product to end customers through a retailer. The time horizon is divided into two periods, and the demand is realized at the end of the second period. From the retailer's perspective, market demand is a random variable, D, that follows a probability distribution with support on $[0,R]$. We define $F(\cdot)$ as the cumulative density function (cdf) of D and $f(\cdot)$ as its probability density function (pdf). In addition, $\overline{F}(\cdot) := 1 - F(\cdot)$. We assume that the retail price, p, charged to the end customers is exogenously determined. That is, the retailer faces a newsvendor problem, and the only decision the retailer can make is the order quantity, q, that satisfies the end market demand.[1] In this paper, we assume that the leadtime of

[1] The newsvendor setting is commonly used in decentralized supply chain literature such as supply chain contracts (Cachon, 2002 and reference therein) and assembly systems (Bernstein et al., 2007). Adopting such setting helps facilitate the analysis of the retailer's optimal decisions, enabling us to mainly focus on the strategic moves between the manufacturer and the retailer and the optimal strategy in the supply chain.