



Implications of stochastic demand and manufacturers' operational mode on retailer's mixed bundling strategy and its complexity analysis

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ABSTRACT

In this paper, we consider a supply chain consisting of two manufacturers and one retailer producing and retailing complementary products facing stochastic demand. We focus on the retailer's bundling strategy and investigate the impact of the stochastic demand and manufacturers' decisions on the bundling strategy. We find that the manufacturers will make cooperative game to maximize their profits. With manufacturers' cooperative pricing strategy, the retailer will adopt bundling strategy facing a low level uncertain demand. Under severe uncertainty, the retailer will adopt no-bundling strategy to obtain more profits. We work out the critical condition which determines the retailer's retail strategy. We also analyze the stability of the dynamic game system in which the retailer adopts bundling and no-bundling strategy and find that the system in which the retailer adopts no-bundling strategy has a better performance on keeping stability, although the market is more uncertain. Finally, we provide managerial insights for the manufacturers to keep system stable and control the unstable system.

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1. Introduction

Bundling, which offers two or more products as a package, is commonly used by retailers to attract consumers and improve sales, especially for the complementary products. The complementary products, such as camera and film, toothpaste and toothbrush, are usually sold as a package. Bundling benefits both the consumers and the retailer. The consumer gains from reducing the search and transaction cost. Sometimes the bundling provides a cheaper price to the consumer. The retailer can receive greater profits through the demand expansion. However, the retailer needs to find a trade-off between the extended demand and reduced price, especially when the demand is uncertain.

In this paper, we consider a two-echelon supply chain consisting of complementary products and explore the firms' operational strategies for greater profits and more stable supply chain. Two manufacturers producing complementary products decide whether to cooperate with each other, and then the retailer decides whether to adopt bundling strategy. The uncertainty in demand exists and affects the firms' pricing strategy. In practice, the firms can hardly acquire the information including the demand in the current period. The demand uncertainty may further influence the retailer's decision. As a result, the retailer's order quantity can hardly match the demand in each period. No matter the order quantity is more or less than the demand, the retailer may lose. This phenomenon has been described in the classical newsvendor model. We

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derive a dynamic newsvendor model to study the impact of the uncertain demand on the choice of the firms' operational strategies and the system stability.

The event sequence is as follows. At the beginning of each period, the manufacturers decide whether to cooperate with each other and offer wholesale price for each product. Then the retailer decides whether to adopt bundling strategy and the retail prices for the separately sold and bundling (if adopting bundling strategy) products. Due to staying away from the market, the manufacturers know less about the market than the retailer. So we consider the manufacturers are bounded rational and hold incomplete information of the market. They adjust the prices in each period until they are optimal. In the process of dynamic pricing, the Nash equilibrium solution may be not stable, and dynamic game system may be chaos. In a chaos system, the firms cannot obtain the maximum profits. For the manufacturers, they should understand the reason of chaos and the way how to control the chaos, in order to steady the supply chain and receive the maximum profits.

Literature gives no clear definition about which phenomenon is chaos in the supply chain. However, the unstable decision widely exists in the supply chain and other economic systems. For instance, in an agricultural product market, farmers decide which to plant at the beginning of each year according to the sales and prices in the last year. It is very common to see that the fluctuation in crops' prices is great year after year. This phenomenon is mainly due to the farmers' blind behavior. Take the corn for example, if the supply falls short of demand in the last year, most of the farmers may select to plant it in this year, leading to the oversupply and low price in this year. Then a large number of farmers turn to plant others in the next year, resulting in the supply shortage. The prices and sales are constantly fluctuating year after year. No stable equilibrium solutions appear if the farmers keep adjusting their decisions drastically. In this paper, we explain this phenomenon by developing a pricing system in which the manufacturers and retailer determine the prices and other operational strategies. We show the influence of the uncertain demand on the operational strategy. As to the system stability, we demonstrate that if the uncertainty demand is with a relatively larger fluctuation range, or the bounded rational manufacturers adjust their decisions drastically, the pricing system will lose control and then the retailer's decision will also be influenced. We explain the reason of chaos and provide the managerial insights for the firms to control the system.

The rest of this paper is organized as follows: the literature review is shown in [Section 2](#). In [Section 3](#), the model and supply chain structure is described. In [Section 4](#), the comparison between bundling and no-bundling strategy is made to guide the manufacturers' and retailer's decision. The dynamic properties of the pricing system are presented in [Section 5](#), and [Section 6](#) concludes. The detailed proofs and discussion are left to the appendix.

2. Literature review

The bundling strategy is widely used by the retailer to sell the complementary products. Bhargava [1] considers the bundling problem of independently valued goods. He identifies the condition under which bundling strategy is adopted based on the consumers' utility perception, and shows that in most cases, the retailers will bundle the complementary products because the consumers who buy one product may also need the other one. Yan and Bandyopadhyay [2] study the bundling strategy of complementary products and give the condition of adopting bundling strategy. They also find that the value of bundling price increases with bundling discount price sensitivity and the size of market. Yan et al. [3] analyze the impact of advertising on the bundling strategy of complementary products, demonstrating that advertising can help bundling strategy make a better performance. Taleizadeh and Charmchi [4] develop a research with the consideration of the manufacturers' decisions and the advertising cost sharing between the manufacturers and retailer.

For the retailer, bundling strategy can capture a better consumer surplus [5] because when the consumers buy something separately, they will compare its price to another one, which may reduce the consumer surplus and the sales more or less. Bitran and Ferrer [6] analyze a company's reaction to the bundling strategy made by its leader in the industry. They propose an efficient method to determine the optimal price and composition of the bundle. The firms adopting bundling strategy would bundle products and sell them at a bundling prices. The bundling price can be higher or lower than the sum of the products sold separately. If the good is in short supply, the retailer can bundle others with it and present a discriminated price. On the other hand, if the good is oversupplied in the market, the retailer has to bundle them with a lower price. This paper considers the latter scenario, in which the bundling marketing strategy may raise the sales but lower the profits per unit. The retailers who maximize profits need to balance the sales growth and unit profit decline based on the market information such as the market size, the consumer expectation and even the fluctuations in demand. Whether to adopt bundling strategy? Some bundling research has focused on this problem in different situations. McCardle et al. [7] investigate the bundling strategy of basic and fashion products and find that the profitability of bundling depends on individual product demands, bundling costs and the relationship between the demands of products to be bundled. When the capacities limited by the resources, the availabilities of resources and the quality of the products will also affect the optimal bundling strategy [8]. Prasad et al. [9] focus on the bundling strategy of high-tech products with network externality, analyzing the impact of asymmetry or symmetry in network externality and cost on the choice of bundling strategy.

It is very common to see the tangible products are sold in bundle. However, the virtual product can also be bundled as a package. Some handset manufacturers cooperate with telecommunication operators and sell contract machines. The consumers can get both contract handset and communication fee with the price of a common phone, while they need to promise a minimum monthly expense. Some telecommunication operators render services of advance communication fee. The consumers who advance communication fee can get a phone for free. Yang and Ng [10] investigate the pricing problem for wireless telecommunication product bundling service and give advice to the service providers on how to choose bundling

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