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TWO-PERIOD PRICING STRATEGIES IN A TWO-ECHELON SUPPLY CHAIN WITH CONSPICUOUS CONSUMPTION

Rongjing Zhu and Musen Xue*

Abstract. This paper investigates the problem of pricing strategies in a two-echelon supply chain with conspicuous consumers. We develop a two-period pricing model for the supply chain which is consisted of one manufacturer and one retailer who involve in trading a single product. The manufacturer being a Stackelberg leader, decides the wholesale price, the retailer acts as a follower and sets the selling price. As a leader, the manufacturer has two pricing options: (1) sets a common wholesale price for the entire selling season; (2) sets two different wholesale prices for the two selling periods respectively. Based on the manufacturer's pricing options, we develop four pricing cases considering the effect of conspicuous consumption and compare the equilibrium outcomes. In addition, we study the impacts of the main parameters on the equilibrium results under different cases in the numerical study and obtain some managerial insights.

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1. Introduction

In practice, many products undergo different market conditions over their product life cycles. Firms would adjust prices to respond the changing market conditions. For instance, in February 2013, Sony reduced the price of PS Vita in Japan by 30% about a year after the product was released to the market, one of the major reasons is Japan's current exchange rate [33]. The same situation occurs in fashion industry, some luxury fashion brands such as LV and Coach would sell the products with obsolete styles at discount prices in their factory outlets when they are launching a new style, as well as some other brands which will not launch new styles just cut the prices of the same products [41]. Anticipating this two-period pricing policy, consumers are able to time their consumption to maximize their own utility.

It has been widely accepted that consumer's purchase decision relies not only on the material needs satisfied by the product, but also on social needs [2]. Consumers who frequently express themselves by consuming goods prominently with the purpose to display their status and signal their uniqueness and exclusivity are called conspicuous consumer [34]. Conspicuous consumption products such as luxury goods, designer brands, digital cameras, smart phones, etc., have called for additional attention. The demand of those goods is not only affected by the price, but also by the conspicuous value. For example, in our real life, it is a common phenomenon that

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School of Management, Tianjin Normal University, Tianjin 300387, P.R. China
* Corresponding author: msxue@tju.edu.cn

people make a display of their personal belongings by uploading the pictures on the social networks to attract others' attention.

Facing the consumers' conspicuous behavior, firms often provide products with unique designs and forms. A firm may take some ways such as brand name, limited supply and expensive price to highlight the uniqueness and exclusivity of its own to others. The strength of brand name often implies a firm's economic superiority, which brings the ability to stand out and yield status or greater conspicuous consumption [25]. This indicates that it is important to realize the significance of brands and how brands gain a certain status from consumers. Meanwhile, there is substantial evidence that personal welfare is influenced by comparisons with others [36], and consumers could value a product more as less consumers possess the same product. Thus, a firm may limit production to restrict the availability and improve the uniqueness and exclusivity of its product. For example, Ferrari makes a promise that it will not produce more than 4300 vehicles in spite of a more than two-year waiting list [3]. In addition, expensive price could stimulate the purchasing behavior of conspicuous consumers despite the products have neither quality differences nor any signal value [1]. Therefore, firms would set expensive prices to increase the uniqueness and exclusivity for their products. Modern examples include luxury cars, fashion clothes and obscure vintages of wine. Firms usually face a challenge on how to pricing and make decision strategies when selling products to such conspicuous consumers.

Based on the above realities, we present a two-period pricing model to investigate pricing strategies for a manufacturer-retailer supply chain with conspicuous consumption. Encountering the conspicuous behavior of consumers, the manufacturer has three pricing strategies: (1) static pricing, which means that the manufacturer would set a common wholesale price for the entire selling season at the beginning of the first period; (2) price commitment, under which the manufacturer would pre-announce two different wholesale prices respectively for the two periods at the beginning of the first period, and the manufacturer would credibly commit to this preannounced price path; (3) dynamic pricing, which indicates that the manufacturer declares only the first-period wholesale price at the beginning of the first period, and delays the second-period wholesale price announcement until the beginning of the second period. The retailer who sells a single product to a fixed population of consumer in two periods has two options of pricing strategy: (1) price commitment, under which the retailer declares two different selling prices in advance for the two periods at the beginning of the selling season, and commits to follow this price path; (2) dynamic pricing, in which the retailer announces the first-period selling price at the beginning of the first period and does not declare the second-period selling price until the first period is over.

We develop a Stackelberg game between the manufacturer and the retailer, where the manufacturer as a leader decides the wholesale price and the retailer being a follower decides the selling price. To compare the different pricing strategies, we consider the game in four cases: (1) the manufacturer adopts static pricing while the retailer adopts price commitment (Case I); (2) both the manufacturer and the retailer choose price commitment (Case II); (3) the manufacturer employs static pricing and the retailer employs dynamic pricing (Case III); (4) both the manufacturer and the retailer take the strategy of dynamic pricing (Case IV). Although some researchers have studied the pricing problem of conspicuous consumption (*e.g.* [31, 34, 38]), the research on conspicuous consumption has been largely overlooked in supply chain management. In view of this gap, we try to answer the following questions: (1) what are the equilibrium pricing strategies for the manufacturer and the retailer in the four cases; (2) which kind of pricing strategies is better for each supply chain member and the whole supply chain; (3) how does the conspicuous behavior of consumer affect the pricing decisions and the equilibrium profits.

To answer these research questions, we present a two-period pricing model in supply chain, and obtain the equilibrium strategies under different cases. The main results show that when the manufacturer adopts static pricing and the retailer adopts price commitment (Case I) or both the manufacturer and the retailer adopt price commitment (Case II), it is a counterintuitive view that the second period selling price increases in rationing level. In other words, the retailer can charge a higher selling price in the second period with a higher rationing level to reap profit under Cases I and II. Besides, under Case I, the profit of the retailer is higher than the profit of the manufacturer when the consumers have a strong incentive of conspicuous consumption. This indicates that the manufacturer who takes a dominate place would lose the first-mover advantage due to the conspicuous consumption in a supply chain. In addition, when the level of consumers' sensitivity to non-availability is sufficiently high, the first period selling prices of the retailer would exceed the superior limit of consumers' valuation on the product. This means that conspicuous consumption can extent the retailer's pricing space. Moreover, the profits of the manufacturer, the retailer and the whole supply chain can benefit from rationing, except the Case III under which the manufacturer would obtain a higher profit with a sufficiently high level of rationing. This suggests that the manufacturer would desire to satisfy all the demands without placing any restriction on availability when the manufacturer adopts static pricing and the retailer adopts dynamic pricing. We also find that under Case IV, there is a chance that the manufacturer and the retailer as well as the whole supply chain would achieve the highest profits in comparison with the other three cases. In other worlds, it is possible for the manufacturer, the retailer and the whole supply chain to reach a Pareto outcome when both the manufacturer and the retailer employ dynamic pricing.

The rest of this paper is organized as follows. In Section 2, we give a simple review of the previous literature related to this paper. Section 3 provides notations and develops a two-period model with conspicuous consumption. We exhibit the equilibrium results under different cases in Section 4 and compare the equilibrium results in Section 5. In Section 6, we present a numerical example to analyze the sensitivity of the main parameters. Section 7 includes our conclusions and future research directions.

2. Literature review

With the rapid development of technology, products with fast updating and short life cycle are characterized by high demand uncertainties and finite number of decision-making opportunities. As a result, single period pricing policy is often adopted to analyze operational issues related to such products in the literature. Lin and Ho [17] explore the optimal pricing and ordering strategies for an integrated inventory system when the vendor offers a quantity discount to the buyer. Ghosh and Shah [10] and Modak *et al.* [21] discuss the pricing policies for the manufacturer and the retailer when they have greening costs. Karray and Sigue [14] discuss the optimal choice of three firms where one firm sells an independent product and the rest two firms sell complementary products. Modak *et al.* [22] address the issues of pricing, replenishment policies, coordination and surplus profit division among the members of the dual-channel supply chain. In their model, the cost of the product decreases continuously over product's life time. Panda *et al.* [29] and Modak *et al.* [24] study the problem of channel coordination and benefit sharing in a three-echelon supply chain. Xu and Liu [37] investigate the impacts of reference price on the pricing strategies under three different channels in a closed loop supply chain. Some researchers explore channel coordination and profit distribution in the supply chain under the consideration of corporate social responsibility (*e.g.* [12, 23, 28, 30]).

In reality, some products with long life cycle, such as fashion clothes, vogue handbags etc., which can provide multiple decision opportunities for firms over the selling season. Thus, two-period or multi-period pricing models are often used for these products in the relative literature. Two-period or multi-period pricing strategy are regarded as a sort of dynamic strategy which has been adopted by many researchers during the past few years (*e.g.* [8, 35, 40]). Some researchers deal with the pricing problems considering the factor of inventory in two-period or multi-period models, such as [4, 6, 15]. Some other researchers investigate the effects of demand on pricing decisions. For instance, Pan *et al.* [27] construct a two-period model with demand uncertainty to discuss pricing and ordering problems for a retailer who takes a dominant place in the market. Maiti and Giri [19] investigate the problem of two-period pricing and decisions for a two-echelon supply chain with price-dependent demand, they also study the effects of the decision strategies on the optimal results of the supply chain. Several papers address pricing issues from other perspectives. Dasci and Karaku [7] develop a two-period model to analyze the impact of dynamic and fixed-ratio pricing policies on firm profits and equilibrium prices under the condition of competition. Güler *et al.* [11] investigate a periodic review joint replenishment and pricing problem of a single product with reference price effect through the multi-period joint setting. Zhou *et al.* [41] propose a two-period pricing model for a firm who sells a fashion product to the customers, they illustrate the best choice and optimal retail prices under three different strategies for the firm. Li *et al.* [16] take the competition between new and out-of-season products into consideration and investigate a multi-period ordering and clearance pricing model. However, most of the literature mentioned above do not take the consumers' behaviors into account. We differ from their work by incorporating the effect of conspicuous behavior into our model. Our model allows us to disentangle how conspicuous consumption affects the selection of pricing strategy under a supply chain framework.

Several papers have discussed the problem of pricing strategy with conspicuous consumption. Caulkins *et al.* [5] consider the problem of pricing a conspicuous product when the economy is in a recession. They incorporated recession effects which can reduce demand and freeze capital markets into their model. Rao and Schaefer [31] develop an analytical model considering conspicuous consumption to investigate firms' marketing strategy. In their paper, both pricing and product management decisions are examined for conspicuous durable goods. Huschto and Sager [13] study the problem of pricing conspicuous consumption products when the economy is in a recession period with uncertain duration and strength. Besides, they compare different optimization methods under uncertainty in the context of pricing policies for conspicuous products. Xue *et al.* [38] propose a two-period model to study supply chain pricing and coordination with markdown strategy considering conspicuous consumption. The results show that the supply chain can benefit from conspicuous consumption.

To the best of our knowledge, there is a little of research considering the pricing strategies for supply chain with conspicuous consumption. In view of this gap, we build a two-period pricing model under the framework of one manufacturer-retailer in supply chain and formulate four different pricing cases to compare them.

3. Model formulation

Consider a supply chain consisting of one manufacturer (denoted by subscript "m") and one retailer (denoted by subscript "r"). The manufacturer acts as a Stackelberg leader decides the wholesale price and the retailer as a follower decides the selling price. To have a better description of our model, the following notations are applied throughout this paper:

d_1	Market demand of the retailer in the first period.
d_2	Market demand of the retailer in the second period.
v	Consumers' valuation on the product.
c	Unit cost of the product.
w	Common wholesale price of the manufacturer for both periods.
w_1	Wholesale price of the manufacturer in the first period.
w_2	Wholesale price of the manufacturer in the second period.
p_1	Selling price of the retailer in the first period.
p_2	Selling price of the retailer in the second period.
θ	Rationing level of the retailer in the second period.
k	Consumer's sensitivity to non-availability.
u	Consumer's utility.
π_m	Profit of the manufacturer.
π_r	Profit of the retailer.
π_t	Profit of the whole supply chain, *i.e.*, $\pi_t = \pi_m + \pi_r$.

The manufacturer produces a single product and sells it to the retailer by a traditional channel for satisfying the market demand in two consecutive selling periods. Following Fudenberg and Tirole [9], Özer and Zheng [26] and Maiti and Giri [19], it is supposed that the lead time is zero, and we doesn't consider the length of the selling period and holding cost in order to make the model more tractable. The unit cost of product is a constant denoted by $c > 0$. The manufacturer takes two different pricing options: (1) sets a common wholesale price w for the entire selling season; (2) sets two different wholesale prices w_1 and w_2 respectively for the two periods. Facing the above pricing options, the retailer sets two different selling prices p_1 and p_2 respectively for the two periods.

Consumers notice the price announcements and make their purchasing decisions. Equal to Zhang and Cooper [39] and Shum *et al.* [32], the consumers have heterogeneous valuations v on the product, which is subjected to uniform distribution on the support of [0,1]. Consistent with Mersereau and Zhang [20] and Liu and Shum [18], we regard u as consumers' utility which is not discount over time. Each consumer has unit demand and remains in the market until the selling season is over. The demands of the consumers are denoted by d_1 and d_2 for the two periods, respectively. Without loss of generality, the size of the market is deterministic, which is normalized to 1.

Following Zhang and Cooper [39], in the second period, the retailer would create a rationing level θ $(0 \leq \theta < 1)$ to limit the availability of the product. When $\theta = 0$, the retailer only sells the product in the first period. When $\theta > 0$, the retailer sells the product in both periods. The consumer has a equal chance to get the product with the probability of θ in the second period, which means that the consumers' demand would not be fully satisfied. On the contrary, the consumer who purchases the product in the first period would avoid the non-availability risk. Following Xue *et al.* [38], we construct a utility function for the consumers who purchase in the first period with the belief in non-availability $1 - \theta$ and the utility function is

$$u_1 = v + k(1 - \theta) - p_1. \tag{3.1}$$

In equation (3.1), u_1 represents the first-period utility of consumers and k denotes the sensitivity to non-availability. The higher the value of k, the greater the consumer's incentive to conspicuous consumption. For the sake of simplification, we assume that $k \in [0, 1]$. When $k = 0$, the consumers in the market without any conspicuous consumption; When $k = 1$, the consumers take complete conspicuous consumption.

Consumers who choose to purchase in the second period would confront with the selling price p_2 and the retailer's rationing level θ. The utility function is given as:

$$u_2 = \theta(v - p_2)^+, \tag{3.2}$$

where $(x)^+ = \max\{0, x\}$. u_2 denotes the utility of the consumers who choose to purchase the product in the second period. With a given rationing level, the consumer makes purchasing decision by the utility obtained from consuming the product. When

$$u_1 \geqslant u_2, \tag{3.3}$$

which means that the consumer's utility obtained from purchasing the product in the first period is higher than that in the second period. Thus, the conspicuous consumers would buy the product in the first period. Otherwise, if $u_1 < u_2$, they would choose to wait in the first period. From equation (3.3), we get a threshold denoted by $\tilde{v}$, as follows,

$$\tilde{v} = \frac{p_1 - k(1 - \theta) - \theta p_2}{1 - \theta}, 0 \leq \theta < 1. \tag{3.4}$$

In summary, a conspicuous consumer would choose to purchase in the first period if and only if his valuation $v \geq \tilde{v}$; when $p_2 \leq v \leq \tilde{v}$, a conspicuous consumer would choose to buy the product in the second period. From the equation (3.4), we obtain the market demand equations respectively for the two periods which are given as:

$$d_1 = 1 - \tilde{v}, \tag{3.5}$$

$$d_2 = \tilde{v} - p_2. \tag{3.6}$$

4. Pricing cases

In this section, we will exhibit four different pricing cases caused by different pricing strategies, *i.e.*, static pricing, price commitment or dynamic pricing. The equilibrium results are presented respectively in the following propositions. All the proofs of the propositions are given in Appendix A.

4.1. Case I

In this case, both the manufacturer and the retailer announce their own full price path at the beginning of the selling season. The manufacturer adopts static pricing while the retailer adopts pricing commitment. The decision sequence as: first, the manufacturer sets a common wholesale price w for the entire selling season; then, the retailer declares his selling prices p_1 and p_2 respectively for the two periods. In view of the aforementioned scenarios, the total profits of the manufacturer and the retailer are characterized as follows:

$$\pi_m^I = (w - c)(d_1 + d_2), \tag{4.1}$$

$$\pi_r^I = (p_1 - w)d_1 + (p_2 - w)d_2. \tag{4.2}$$

We maximize the total profit functions respectively to obtain the equilibrium results which are given in the following proposition.

Proposition 4.1. *[38]. Under Case I, the equilibrium pricing strategies of the manufacturer, the retailer as well as the equilibrium profits of the manufacturer, the retailer and the whole supply chain are given respectively by:*

$$w^I = \frac{2 + 2c + k - k\theta}{4} \tag{4.3}$$

$$p_1^I = \frac{2c(1+\theta) - (k(\theta-1) - 2)(5+\theta)}{4(3+\theta)} \tag{4.4}$$

$$p_2^I = \frac{2+k}{2} + \frac{c - 2k - 1}{3+\theta} \tag{4.5}$$

$$\pi_m^I = \frac{(2c + k(\theta-1) - 2)^2}{8(3+\theta)} \tag{4.6}$$

$$\pi_r^I = \frac{4 + 4c^2 + 4c(k(\theta-1) - 2) - k(\theta-1)(4 + k(13+3\theta))}{16(3+\theta)} \tag{4.7}$$

$$\pi_t^I = \frac{12 + 12c^2 + 12c(k(\theta-1) - 2) - k(\theta-1)(12 + k(15+\theta))}{16(3+\theta)} \tag{4.8}$$

4.2. Case II

In this case, both the manufacturer and the retailer adopt price commitment. They give the full price path at the beginning of first period. The decision sequence as: first, the manufacturer announces two different wholesale prices w_1 and w_2 respectively for the two periods; following the manufacturer's action, the retailer declares two different selling prices p_1 and p_2 respectively for the two periods. Under this case, the total profits of the manufacturer and the retailer are specified respectively as follows:

$$\pi_m^{II} = (w_1 - c)d_1 + (w_2 - c)d_2, \tag{4.9}$$

$$\pi_r^{II} = (p_1 - w_1)d_1 + (p_2 - w_2)d_2. \tag{4.10}$$

The equilibrium results are obtained by maximizing the total profit functions respectively, which are exhibited in the following proposition.

Proposition 4.2. *Under Case II, the equilibrium pricing strategies of the manufacturer and the retailer as well as the equilibrium profits of the manufacturer, the retailer and the whole supply chain are given respectively by:*

$$w_1^{II} = \frac{1+c+k-k\theta}{2} \tag{4.11}$$

$$w_2^{II} = \frac{1+c}{2} \tag{4.12}$$

$$p_1^{II} = \frac{5+\theta+c(1+\theta)-k(\theta-1)(4+\theta)}{2(3+\theta)} \tag{4.13}$$

$$p_2^{II} = \frac{2+k}{2} + \frac{c-2k-1}{3+\theta} \tag{4.14}$$

$$\pi_m^{II} = \frac{1+c^2+c(-2+k(-1+\theta))-k(1+k)(-1+\theta)}{2(3+\theta)} \tag{4.15}$$

$$\pi_r^{II} = \frac{1+c^2+c(-2+k(-1+\theta))-k(1+k)(-1+\theta)}{4(3+\theta)} \tag{4.16}$$

$$\pi_t^{II} = \frac{3(1+c^2+c(-2+k(-1+\theta))-k(1+k)(-1+\theta))}{4(3+\theta)} \tag{4.17}$$

4.3. Case III

Under this case, the manufacturer employs static pricing while the retailer employs dynamic pricing. The decision sequence as: at the beginning of the selling season, the manufacturer first sets a common wholesale price w for both the periods and then the retailer only gives the first-period selling price p_1; at the end of the first period, the retailer declares the second-period selling price p_2. Based on the scenarios mentioned above, the total profit functions of the manufacturer and the retailer are written respectively as:

$$\pi_m^{III} = (w-c)(d_1+d_2), \tag{4.18}$$

$$\pi_r^{III} = (p_1-w)d_1 + (p_2-w)d_2. \tag{4.19}$$

We use backward induction to find the retailer's equilibrium pricing strategies, while the equilibrium pricing strategy of the manufacturer is obtained by maximizing the manufacturer's total profit function. The equilibrium results are shown in the following proposition.

Proposition 4.3. *Under Case III, the equilibrium pricing strategies of the manufacturer and the retailer as well as the equilibrium profits of the manufacturer, the retailer and the whole supply chain are given respectively by:*

$$w^{III} = \frac{2+2c+k-k\theta}{4} \tag{4.20}$$

$$p_1^{III} = \frac{2c+(-2+k(-1+\theta))(-5+4\theta)}{12-8\theta} \tag{4.21}$$

$$p_2^{III} = \frac{-8 + 2c(-2+\theta) + k(-2+\theta)(-1+\theta) + 6\theta}{-12 + 8\theta} \tag{4.22}$$

$$\pi_m^{III} = \frac{(-2 + 2c + k(-1+\theta))^2(-2+\theta)}{-48 + 32\theta} \tag{4.23}$$

$$\pi_r^{III} = \frac{(\theta-1)(4 + 4c^2 + 4c(k(\theta-1)-2) + k(4 - 4\theta + k(13 + (\theta-10)\theta)))}{-48 + 32\theta} \tag{4.24}$$

$$\pi_t^{III} = \frac{4 + 4c^2 + 4c(-2 + k(\theta-1)) + 4(-4 + k(\theta-5))(\theta-1)}{16} \tag{4.25}$$

4.4. Case IV

Under this case, both the manufacturer and the retailer take dynamic pricing strategy. The decision sequence as: at the beginning of the selling season, the manufacturer first announces the first-period wholesale price w_1 and then the retailer declares the first-period selling price p_1; at the beginning of the second period, the manufacturer gives the second-period wholesale price w_2 and then the retailer declares the second-period selling price p_2. Under the circumstances mentioned above, their total profit functions are given respectively as follows:

$$\pi_m^{IV} = (w_1 - c)d_1 + (w_2 - c)d_2, \tag{4.26}$$

$$\pi_r^{IV} = (p_1 - w)d_1 + (p_2 - w)d_2. \tag{4.27}$$

Both the manufacturer and the retailer's equilibrium pricing strategies are obtained by backward induction. We exhibit the equilibrium results in the following proposition.

Proposition 4.4. *Under Case IV, the equilibrium pricing strategies of the manufacturer and the retailer as well as the equilibrium profits of the manufacturer, the retailer and the whole supply chain are given respectively by:*

$$w_1^{IV} = \frac{-242 - 206c - 208k + \theta A - \theta^2 B + \theta^3 C - 108k\theta^4}{4(3\theta-4)^2(6\theta-7)} \tag{4.28}$$

$$w_2^{IV} = \frac{(\theta-1)(-46 + k(4-3\theta)^2 + 36\theta) + c(66 - 98\theta + 36\theta^2)}{4(3\theta-4)(6\theta-7)} \tag{4.29}$$

$$p_1^{IV} = \frac{c(10-8\theta) - (\theta-1)(46 - 36\theta + k(3\theta-4)(9\theta-10))}{2(3\theta-4)(6\theta-7)} \tag{4.30}$$

$$p_2^{IV} = \frac{3(\theta-1)(-46 + k(4-3\theta)^2 + 36\theta) + 2c(43 + 3\theta(6\theta-19))}{8(3\theta-4)(6\theta-7)} \tag{4.31}$$

$$\pi_m^{IV} = \frac{(\theta-1)(k(4-3\theta)^2 D + 36(3-2\theta)^2 E)}{16(4-3\theta)^2(6\theta-7)} \tag{4.32}$$

$$\pi_r^{IV} = \frac{(\theta-1)(-4636E + 3k(4-3\theta^2)(4\theta-5)D + 48\theta EF)}{64(7-6\theta)^2(4-3\theta)^2} \tag{4.33}$$

$$\pi_t^{IV} = \frac{(\theta-1)(k(4-3\theta)^2(36\theta-43)D + 4(18\theta-23)EG}{64(7-6\theta)^2(4-3\theta)^2} \tag{4.34}$$

where $A = 614 + 442c + 712k$, $B = 516 + 312c + 909k$, $C = 144 + 72c + 513k$ $D = k(4-3\theta)^2 + 4(c-1)(6\theta-5)$, $E = c^2 - 2c + 1$, $F = 212 + 9\theta(4\theta-17)$, $G = 149 + 6\theta(12\theta-35)$.

5. Comparison and discussion

In this section, we mainly discuss and compare the equilibrium results under Cases I, II and III. The equilibrium results under Case IV are too complicated to compare with the equilibrium results under the other three cases. Thus, we would compare the four cases in the numerical study.

Proposition 5.1. *$w^I = w^{III}$ and $w_2^{II} > w_2^{IV}$.*

From Proposition 5.1, we can see that the wholesale price in Case I is equal to the wholesale price in Case III. This indicates that when the manufacturer chooses static pricing, the pricing decision of the manufacturer is not influenced by the retailer no matter which pricing strategy the retailer will choose, and the manufacturer would charge the same wholesale price to the retailer. In addition, the wholesale price in the second period under Case II is higher than that in the second period under Case IV. This suggests that the manufacturer would set a higher wholesale price under price commitment than dynamic pricing in the second period.

Proposition 5.2. *$p_1^i > p_2^i$, where $i \in \{I, II, III, IV\}$.*

Proposition 5.2 shows that the selling price of the retailer in the first period is always higher than the selling price in the second period under any of these four pricing cases. This indicates that the retailer would take a markdown policy when he sells the product to conspicuous consumers. There are two reasons for the retailer to adopt markdown policy: (1) conspicuous consumption can help to improve the first-period's demand and the retailer would set a higher selling price to reap profit; (2) in the second period, the retailer would like to attract more purchases by cutting the selling price. In practice, this markdown strategy is very prevalent. When firms release a new product to the market, they will set a higher selling price for a certain time. But, after a certain time, firms are willing to reduce the selling price to keep a high demand rate. We can see declining selling prices of the electronic goods throughout their life cycles in the market, such as PCs, digital cameras, mobile phones, fashion and textiles products, etc. [19].

Proposition 5.3. *$p_1^{III} < p_1^I < p_1^{II}$ and $p_2^{III} < p_2^I = p_2^{II}$.*

Proposition 5.3 reveals that the first-period selling price in Case III is lower than the first-period selling prices in Cases I and II, and the selling price in the second period under Case III is also lower than the selling prices in the second period under Cases I and II. This suggests that when the manufacturer employs static pricing or price commitment, the retailer would set lower selling prices with dynamic pricing than price commitment. In addition, the selling price of the first period in Case II is higher than the selling price of the first period in Case I. Even if the retailer adopts the same pricing strategy (price commitment) under Cases I and II, the first-period pricing decision of the retailer is affected by the manufacturer. The retailer would set a higher first-period price when the manufacturer chooses price commitment. Particularly, the value of the second-period selling price under Case I is equal to the second-period selling price under Case II. This indicates that the retailer would set the same second-period selling price with adopting price commitment strategy.

Proposition 5.4. *$\pi_m^I < \pi_m^{II}, \pi_m^I < \pi_m^{III}$ and $\pi_r^I > \pi_r^{II}, \pi_r^I > \pi_r^{III}$.*

From Proposition 5.4, we find that the profit of the manufacturer under Case I is lower than that in the other two cases (II and III), while the profit of the retailer in Case I is higher than that in the other two cases (II and III). Thus, the manufacturer would have a strong motivation to avoid Case I, while the retailer is looking forward to Case I happening. This suggests that there exit a conflict between the manufacturer and the retailer. A similar situation occurs when the manufacturer adopts static pricing. There are two pricing options for the retailer after the manufacturer adopted static pricing: (1) price commitment (Case I), which can bring a lower profit for the manufacturer and a higher profit for the retailer; (2) dynamic pricing (Case III), which can generate a higher profit for the manufacturer and a lower profit for the retailer. With the purpose of reaping a higher profit, the retailer would prefer to employ price commitment while the manufacturer wants the retailer to adopt dynamic pricing rather than price commitment.

TABLE 1. The equilibrium results under different cases.

Case	w	w_1	w_2	p_1	p_2	π_r	π_m	π_t
I	0.5850	–	–	0.8789	0.7061	0.0813	0.1426	0.2239
II	–	0.6200	0.5500	0.9139	0.7061	0.0730	0.1461	0.2191
III	0.5850	–	–	0.8679	0.6565	0.0756	0.1666	0.2422
IV	–	0.6151	0.4231	0.8926	0.5846	0.0873	0.1697	0.2570

6. Numerical study

In this section, a numerical example is given to illustrate the above theoretical results. Also, sensitivity analysis is presented to examine the impacts of some main parameters on the equilibrium results under four different cases to gain some managerial insights.

6.1. Numerical example

We list the parameter value as: $c = 0.1, k = 0.2, \theta = 0.3$. According to Propositions 4.1–4.4, we can obtain the optimal pricing strategies and the corresponding profits of the manufacturer and retailer, which are given in Table 1.

6.2. Sensitivity analysis of θ on the equilibrium results

We take the parameter value as: $c = 0.1, k = 0.2$ and make a sensitivity analysis for the parameter θ on the equilibrium results in this section. We first examine the impacts of θ on the equilibrium prices which are shown in Figure 1. There are several observations from these figures.

The parameter θ has a negative effect on the first-period selling prices (see Fig. 1a). Because, the retailer would provide more products to the market in the second period with θ increasing, which can reduce the second-period's non-availability risk of consumers. More consumers are encouraged to wait in the first period and expect a lower second-period's selling price. Meanwhile, the advantage of product's uniqueness and exclusivity would wear off as θ increases, which results in fewer purchases. Therefore, the retailer desires to cut the selling price for the purpose of keeping a high demand rate in the first period.

From Figure 1b, the parameter θ has a positive effect on the second-period prices (p_2^I, p_2^{II}) under Cases I and II. It is a counterintuitive view that the retailer would increase the selling price as more products are offered in the second period. Because raising the second-period prices have two effects: (a) a positive impact on the profits; (b) a negative impact on the demand. The increase in profit by the improving selling price can offset the decrease in profit caused by less demand in the second-period. Thus, the retailer would push up the selling prices in the second period with the rationing level θ increasing under Cases I and II. However, the parameter θ has a negative effect on the second-period prices (p_2^{III}, p_2^{IV}) under Cases III and IV. Because the retailer has to attract more purchases by reducing the selling price for the purpose of counteracting the fall in demand as θ increases in the second period.

The parameter θ has a negative effect on most of the wholesale prices (see Fig. 1c) because the manufacturer acting as a Stackelberg leader has a better understanding of the retailer's pricing decision, thus, most of the wholesale prices follow the same trend with the selling prices. However, the second-period wholesale price (w_2^{II}) under Case II is not influenced by θ, which indicates that the manufacturer's pricing decision in the second period is not affected by the retailer when the manufacturer employs price commitment.

Next, we study the impacts of the parameter θ on the equilibrium profits of the manufacturer, the retailer and the whole supply chain, which are given in Figure 2.

The parameter θ has a negative impact on the retailer's equilibrium profits under all of the four pricing cases so does the the manufacturer's equilibrium profits under the pricing cases of I, II and IV

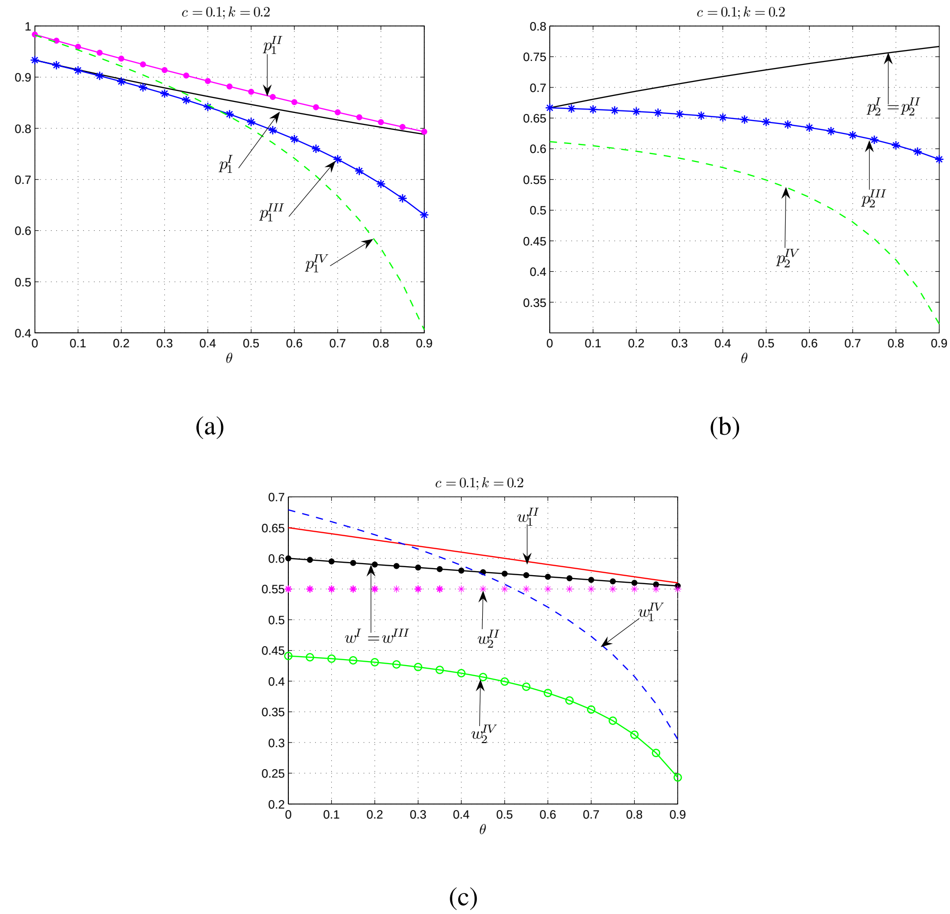

FIGURE 1. Sensitivity of the parameter θ on the equilibrium prices.

(see Figs. 2a and 2b). The reason is that a higher rationing level reduces the non-availability risk in the second period, which encourages more consumers choose to purchase in the second period with a lower selling prices. Thus, the manufacturer and the retailer would be worse off when the retailer creates a higher rationing level in the second period. In particular, we plot the manufacturer's profit curve in Case III with the purpose of having a better observation on it (see Fig. 2c). We find that the profit of the manufacturer decreases first and then increases when θ increases. Because promoting θ has two effects: (a) decreases the manufacture's common wholesale price w^{III} which can result in profit loss; (b) improves the total demand which can bring profit gain. When θ is low, the profit gain can not offset the profit loss, thus the total profit decreases first. When the value of θ is sufficiently high, the profit gain can exceed the profit loss, thus the total profit will increase after θ becoming higher than a critical value.

We find that the parameter θ has a negative impact on the profits of the whole supply chain among all the pricing cases (see Fig. 2d), which means that the whole supply chain would benefit from rationing. There is also an interesting observation: under Case IV, when θ is sufficiently low, the profit of the manufacturer is higher than the other three cases, so does the profits of the retailer and the whole supply chain (see Figs. 2a, 2b and 2d). This indicates that it is possible to achieve a Pareto outcome when both the manufacturer and the retailer adopt dynamic pricing. Thus, with a lower rationing level, both the manufacturer and the

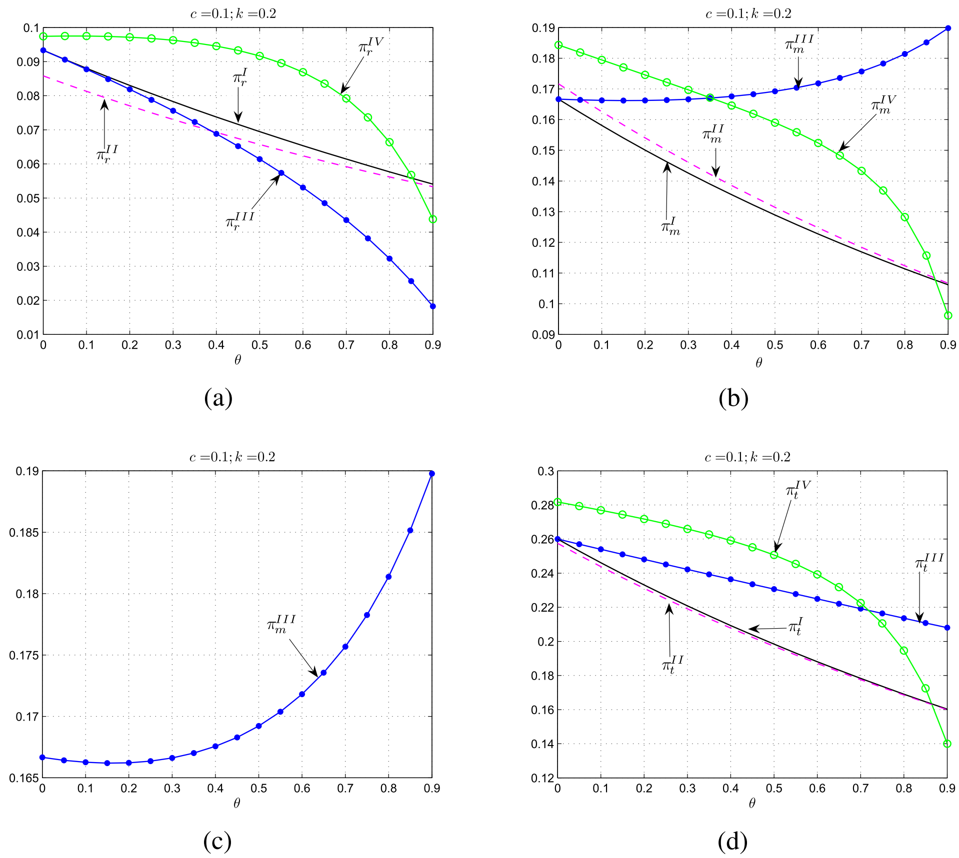

FIGURE 2. Sensitivity of the parameter θ on the equilibrium profits.

retailer are keen to employ dynamic pricing to reap profit. In this situation, the manufacturer and the retailer has no conflict on choosing pricing strategies.

6.3. Sensitivity analysis of k on the equilibrium results

We list the parameter value as: $c = 0.1, \theta = 0.3$, and assess the sensitivity analysis of the parameter k to examine it's impacts on the equilibrium results. According to Figure 3, we give the following observations.

No matter in which case, the first-period selling price always increases with k increasing (see Fig. 3a). Because the higher the k is, the stronger the consumers buying intention is, which can attract more conspicuous consumers to purchase in the first period. Thus, the retailer would set a higher selling price to reap profit in the first period. When the value of k is sufficiently large, the first-period selling price could exceed the upper limit of consumers' valuation which is limited to [0, 1] (see Fig. 3a). This indicates that the consumers' conspicuous behavior could extend the retailer's pricing space, and the retailer would set a higher first-period selling price to skim profit.

The parameter k has a negative impact on the second-period prices among all the strategies. Because as we mentioned above, more conspicuous consumers would choose to purchase in the first period as k increases. Thus, in the second period, the retailer would cut the selling price to keep a high demand.

As we mentioned above, the manufacturer acts as a Stackelberg leader which results in the wholesale prices following the same trend with the retailer's selling prices (see Figs. 3a–3c). However, under Case II, the second-period wholesale price w_2^{II} is not affected by k (see Fig. 3c), which indicates that the manufacturer would set the

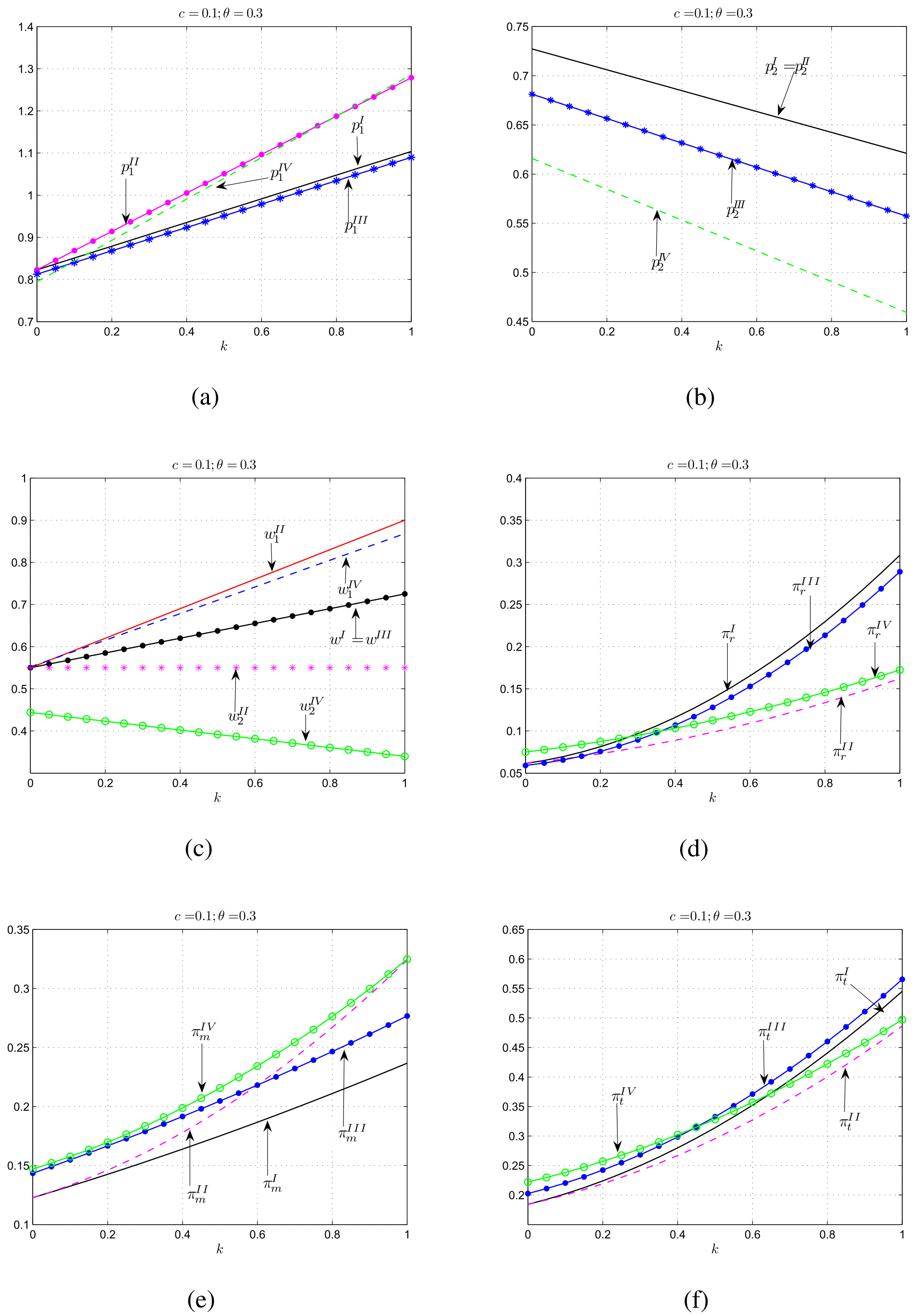

FIGURE 3. Sensitivity of the parameter k on the equilibrium results.

second-period wholesale price without considering the consumers' conspicuous behavior when he adopts price commitment.

Among all the pricing cases, the parameter k has a positive impact on the profit of the manufacturer, the retailer and the whole supply chain (see Figs. 3d–3f). This implies that the manufacturer, the retailer as well as the whole supply chain would obtain more benefits if k has a higher value. Because more conspicuous consumers would choose to purchase in the first period with a higher selling price as k increases, which can generate more profits. We also find several interesting observations when the value of k is sufficiently large: (a) Under Case I, the retailer would obtain the highest profit while the manufacturer would get the lowest profit among all the cases (see Figs. 3d and 3e). Besides, the retailer's profit exceeds the manufacturer's profit which means that the manufacturer would lose the first-mover advantage. Thus, the conspicuous behavior of consumer could help the retailer to make up the disadvantage in the manufacturer-leading supply chain; (b) Under Case III, the profit of the whole supply chain is higher than that of the other three cases (see Fig. 3f), which implies that the manufacturer and the retailer can enjoy the highest profit of the whole supply chain when the manufacturer employs static pricing and the retailer employs dynamic pricing; (c) Under Case IV, the profit of manufacturer is always higher than that in the other three cases (see Fig. 3e), which indicates that the manufacturer has a strong motivation to choose dynamic pricing. However, when the value of k is sufficiently low, the manufacturer, the retailer and the whole supply chain would achieve the highest profits under Case IV (see Figs. 3d–3f), which means that it is possible to generate a Pareto outcome when both the manufacturer and the retailer adopt dynamic pricing. This result implies that reducing the level of conspicuous consumption can induce supply chain members to employ the same pricing strategy leading to eliminate the conflict of pricing strategy selection. This can benefit the supply chain members and the entire supply chain.

7. Conclusions

This paper considers a supply chain which consists of one manufacturer and one retailer who are involved in trading a single product. The main purpose of this paper is to study the effect of conspicuous consumption on different pricing strategies under the framework of supply chain. To achieve this goal, we develop a Stackelberg game between the manufacturer and the retailer where the manufacturer being a leader sets the wholesale price, and the retailer acting as a follower decides the selling price. We obtain the equilibrium results under four different pricing cases and study the impacts of the main parameters on the equilibrium results with the analysis and comparisons.

The main results obtained in this paper have the following managerial insights and implications: (1) Under Cases I and II, the second-period selling price increases in the rationing level, which is nonintuitive. This suggests that the retailer can set a higher two-period selling price to skim profit even though more products are offered to the market in the second period when the retailer chooses to adopt price commitment strategy. (2) When the manufacturer employs static pricing and the retailer employs price commitment (under Case I), conspicuous consumption could assist the retailer to make up for the weak position in a manufacturer-led supply chain. This means that the retailer is willing to embrace conspicuous consumption under Case I. For the manufacturer, it should be carefully to choose static pricing, because the manufacturer would lose the first-mover advantage with the effects of conspicuous consumption under certain conditions. (3) The conspicuous behavior of consumer can extent the retailer's pricing range, which suggests that the retailer can charge a higher first-period selling price to reap profit. (4) Reducing rationing level, *i.e.*, inducing more customers to consume in the first-selling period, does not always generate a higher profit for supply chain members. When the manufacturer applies static pricing while the retailer employs dynamic pricing (Case III), it is more favorable for the manufacturer to obtain a higher profit if the rationing level is sufficiently high. This means that inducing more customers to consume in the second-selling period can benefit the manufacturer in some cases. (5) When both the manufacturer and the retailer adopt dynamic pricing, the manufacturer, the retailer and the whole supply chain can achieve the highest profits than the profits in the other three Cases (I, II and III) when the level of conspicuous consumption is sufficiently low. In other word, it is possible to reach a Pareto outcome when both the manufacturer and the retailer apply dynamic pricing with a sufficiently low level of conspicuous consumption. This result suggests that reducing the level of conspicuous consumption can induce supply chain members to employ the same pricing strategy resulting in eliminating the conflict of pricing strategy selection, which can benefit the supply chain members and the entire supply chain.

Our research can be extended in the following directions. First, for tractability, we do not consider the situation that the length of two selling periods are different, which would generate different holding cost. Future study can take it into consideration. Second, the impact of competition between different firms or products with respect to pricing and conspicuous consumption should be considered in future extensions to this research. Third, we only consider the traditional retail channel, more channel structures such as online channel or dual-channel can be considered to investigate how conspicuous consumption affects the channel strategies. Last, we analyze the model only under the manufacturer-led Stackelberg game, consideration of other Stackelberg games can be taken in the future research.

Appendix A.

A.1. Proof of Proposition 4.1

In Case I, the manufacturer prices statically and first declares the common wholesale price w, then, the retailer adopts price commitment and makes his reaction *via* maximizing the total profit function (4.2) with respect to p_1 and p_2. Solving the first order conditions $\frac{\partial \pi_r^I}{\partial p_1} = 0$ and $\frac{\partial \pi_r^I}{\partial p_2} = 0$ simultaneously, the optimal reaction of selling prices can be obtained as:

$$p_1 = \frac{2 + k + w - k\theta + w\theta}{3 + \theta}, \tag{A.1}$$

$$p_2 = \frac{1 + 2w + k(-1 + \theta) + \theta}{3 + \theta}. \tag{A.2}$$

The reaction is unique as the Hessian matrix $H_r^I = \begin{pmatrix} \frac{2}{\theta-1} & \frac{1+\theta}{1-\theta} \\ \frac{1+\theta}{1-\theta} & \frac{2}{\theta-1} \end{pmatrix}$ is negative definite, since $\frac{2}{\theta-1} < 0$ and $|H_r^I| = \frac{4-(1+\theta)^2}{(1-\theta)^2} > 0$. Anticipating the retailer's reaction, the manufacturer would maximize his total profit function (4.1) with respect to w. Since the second order condition $\frac{d^2\pi_m^I}{dw^2} = -\frac{4}{3+\theta} < 0$, we can get the unique equilibrium wholesale price as:

$$w = \frac{2 + 2c + k - k\theta}{4}. \tag{A.3}$$

We can get the equilibrium selling prices of the retailer by substituting (A.3) into (A.1) and (A.2). With these equilibrium prices, we can easily get the equilibrium profits of the manufacturer, the retailer as well as the whole supply chain.

A.2. Proof of Proposition 4.2

In Case I, both the manufacturer and the retailer adopt price commitment. The manufacturer first declares two different wholesale prices w_1 and w_2, and then the retailer reacts the price announcement of the manufacturer by maximizing his total profit function (4.10). We check the Hessian matrix $H_r^{II} = \begin{pmatrix} \frac{2}{\theta-1} & \frac{1+\theta}{1-\theta} \\ \frac{1+\theta}{1-\theta} & \frac{2}{\theta-1} \end{pmatrix}$ is negative definite since $\frac{2}{\theta-1} < 0$ and $|H_r^{II}| = \frac{4-(1+\theta)^2}{(1-\theta)^2} > 0$. Thus, we can solve the first order conditions $\frac{\partial \pi_r^{II}}{\partial p_1} = 0$ and $\frac{\partial \pi_r^{II}}{\partial p_2} = 0$ simultaneously to obtain the unique equilibrium selling prices of the retailer as:

$$p_1 = \frac{2 + k - k\theta + (2 + \theta)w_1 - w_2}{3 + \theta}, \tag{A.4}$$

$$p_2 = \frac{1 + k(-1+\theta) + \theta + w_1 + w_2}{3+\theta}. \tag{A.5}$$

Knowing the reaction of the retailer, the manufacturer sets the wholesale prices by maximizing his total profit function (4.9). Here, substituting (A.4) and (A.5) into the profit function (4.9) and check that the Hessian matrix $H_m^{II} = \begin{pmatrix} \frac{4}{\theta^2+2\theta-3} & \frac{2(1+\theta)}{3-\theta^2-2\theta} \\ \frac{2(1+\theta)}{3-\theta^2-2\theta} & \frac{4}{\theta^2+2\theta-3} \end{pmatrix}$ is negative definite since $\frac{4}{\theta^2+2\theta-3} < 0$ and $|H_m^{II}| = \frac{16-4(1+\theta)^2}{(\theta^2+2\theta-3)^2} > 0$. Therefore, we can get the unique equilibrium wholesale prices of the manufacturer by solving the first order conditions $\frac{\partial \pi_m^{II}}{\partial w_1} = 0$ and $\frac{\partial \pi_m^{II}}{\partial w_2} = 0$ simultaneously as:

$$w_1 = \frac{1+c+k-k\theta}{2}, \tag{A.6}$$

$$w_2 = \frac{1+c}{2}. \tag{A.7}$$

Substituting (A.6) and (A.7) into (A.4) and (A.5), we can get the equilibrium selling prices of the retailer. After that the equilibrium profits of the manufacturer and the retailer as well as the whole supply chain can be easily obtained.

A.3. Proof of Proposition 4.3

In Case III, the manufacturer chooses static pricing and sets a common wholesale price w for the entire selling season, while the retailer adopts dynamic pricing and sets two different selling prices p_1 and p_2 respectively for the two periods. Since the retailer pricing dynamically, we use backward induction to solve the equilibrium selling prices.

At the beginning of the first period, the manufacturer first sets a common wholesale price w for the entire selling season. To find the optimal reaction of the retailer, we first optimize the profit portion of the retailer in the second period $(p_2 - w)d_2$ with respect to p_2. Concavity of the second-period profit can be easily verified by the second order condition $\frac{\partial^2 (p_2-w)d_2}{\partial p_2^2} = \frac{2}{\theta-1} < 0$. Thus, solving the first order condition $\frac{\partial (p_2-w)d_2}{\partial p_2} = 0$, we can obtain the equilibrium selling price for the second period which is given as:

$$p_2 = \frac{w + k(\theta-1) + p_1}{2}. \tag{A.8}$$

Substituting (A.8) into the retailer's total profit function (4.19), and then checking the second order condition $\frac{\partial^2 \pi_r^{III}}{\partial p_1^2} = \frac{3-2\theta}{2(\theta-1)} < 0$. Thus, one can solve the first order condition $\frac{\partial \pi_r^{III}}{\partial p_1} = 0$ to find the equilibrium selling price of the first period which is obtained as:

$$p_1 = \frac{2 + w + k(\theta-1)^2 - 2\theta}{3-2\theta}. \tag{A.9}$$

Substituting (A.8) and (A.9) into the manufacturer's total profit function (4.18), we find that the second order condition $\frac{d^2 \pi_m^{III}}{dw^2} < 0$. Thus, we can solve the first order condition $\frac{d\pi_m^{III}}{dw} = 0$ to obtain the equilibrium wholesale price for the manufacturer as:

$$w = \frac{2 + 2c + k - k\theta}{4} \tag{A.10}$$

The equilibrium selling prices can be obtained by substituting (A.10) into (A.8) and (A.9). And then the equilibrium profits of the manufacturer, the retailer and the whole supply chain would be easily obtained.

A.4. Proof of Proposition 4.4

In Case IV, both the manufacturer and the retailer adopt dynamic pricing. Thus, we use backward induction to find the optimal results. We first maximize the retailer's profit portion $(p_2 - w_2)d_2$ with respect to p_2 during the second period. Checking that the second order condition of this profit portion $\frac{\partial^2 (p_2-w_2)d_2}{\partial p_2^2} = \frac{2}{\theta-1} < 0$. We can solve the first order condition $\frac{\partial (p_2-w_2)d_2}{\partial p_2} = 0$ to get the equilibrium selling price for the second period as:

$$p_2 = \frac{k(\theta-1) + p_1 + w_2}{2}\cdot \tag{A.11}$$

Then, we maximize the manufacturer's profit portion $(w_2 - c)d_2$ in the second period with respect to w_2. Substituting (A.11) into $(w_2-c)d_2$ and we find that the second order condition $\frac{\partial^2 (w_2-c)d_2}{\partial w_2^2} = \frac{1}{\theta-1} < 0$. According to the first order condition $\frac{\partial (w_2-c)d_2}{\partial w_2} = 0$, we get the equilibrium wholesale price for the second period as follows:

$$w_2 = \frac{c + k(\theta-1) + p_1}{2}\cdot \tag{A.12}$$

In the first period, we first maximize the retailer's total profit with respect to p_1 by substituting (A.11) and (A.12) into (4.27). We find that the second order condition $\frac{\partial^2 \pi_r^{IV}}{\partial p_1^2} = \frac{3(5-4\theta)}{8(\theta-1)} < 0$. Thus, from $\frac{\partial \pi_r^{IV}}{\partial p_1} = 0$, the equilibrium selling price in the first period can be obtained as:

$$p_1 = \frac{c - 2c\theta - (\theta-1)(6k\theta - 7k - 8) + (6\theta - 8)w_1}{3(4\theta-5)}\cdot \tag{A.13}$$

Then, we maximize the manufacturer's total profit with respect to w_1 by substituting (A.11), (A.12) and (A.13) into (4.26). Checking that the second order condition $\frac{\partial^2 \pi_m^{IV}}{\partial w_1^2} = \frac{2(4-3\theta)^2(6\theta-7)}{9(5-4\theta)^2(1-\theta)} < 0$. Therefore, one can solve the first order condition $\frac{\partial \pi_m^{IV}}{\partial w_1} = 0$ to find the equilibrium wholesale price in the first period as follows:

$$w_1 = \frac{-242 - 206c - 208k + \theta A - \theta^2 B + \theta^3 C - 108k\theta^4}{4(3\theta-4)^2(6\theta-7)}, \tag{A.14}$$

where $A = 614 + 442c + 712k$, $B = 516 + 312c + 909k$, $C = 144 + 72c + 513k$.

After we get the first-period equilibrium wholesale price, the corresponding prices and the profits of the manufacturer, the retailer and the whole supply chain are easily obtained.

A.5. Proof of Proposition 5.1

From Propositions 4.1–4.4, we obtain:

$$w^I - w^{III} = 0, \tag{A.15}$$

$$w_2^{II} - w_2^{IV} = \frac{(10-8\theta)(1-c) + k(4-3\theta)^2(1-\theta)}{4(3\theta-4)(6\theta-7)} > 0\cdot \tag{A.16}$$

A.6. Proof of Proposition 5.2

From Propositions 4.1–4.4, we obtain:

$$p_1^I - p_2^I = \frac{(1-\theta)(2-2c+k(7+\theta))}{4(3+\theta)} > 0, \tag{A.17}$$

$$p_1^{II} - p_2^{II} = \frac{(1-\theta)(1-c+k(5+\theta))}{2(3+\theta)} > 0, \tag{A.18}$$

$$p_1^{III} - p_2^{III} = \frac{(1-\theta)(2-2c+k(7-5\theta))}{12-8\theta} > 0, \tag{A.19}$$

$$p_1^{IV} - p_2^{IV} = \frac{(1-\theta)((1-c)(46-36\theta)+k(135\theta^2-336\theta+208))}{8(3\theta-4)(6\theta-7)} > 0. \tag{A.20}$$

A.7. Proof of Proposition 5.3

From Propositions 4.1–4.4, we obtain:

$$p_1^{I} - p_1^{II} = \frac{k(\theta-1)}{4} < 0, \tag{A.21}$$

$$p_1^{I} - p_1^{III} = \frac{(2c-2+k(\theta-1))\theta^2}{2(3+\theta)(2\theta-3)} > 0, \tag{A.22}$$

$$p_2^{I} - p_2^{II} = 0, \tag{A.23}$$

$$p_2^{II} - p_2^{III} = \frac{(2c-2+k(\theta-1))(\theta-3)\theta}{4(\theta+3)(3-2\theta)} > 0. \tag{A.24}$$

A.8. Proof of Proposition 5.4

From Propositions 4.1–4.4, we obtain:

$$\pi_m^{I} - \pi_m^{II} = \frac{k^2(\theta-1)}{8} < 0, \tag{A.25}$$

$$\pi_m^{I} - \pi_m^{III} = \frac{(2c-2+k(\theta-1))^2(\theta-3)\theta}{16(\theta+3)(3-2\theta)} < 0, \tag{A.26}$$

$$\pi_r^{I} - \pi_r^{II} = \frac{3k^2(1-\theta)}{16} > 0, \tag{A.27}$$

$$\pi_r^{I} - \pi_r^{III} = \frac{(2c-2+k(\theta-1))^2\theta^2}{16(\theta+3)(3-2\theta)} > 0. \tag{A.28}$$

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