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Highlights

- We investigate a supply chain member's incentive for supply chain price leadership.
- We analyze a game-theoretic model composed of two manufacturers and one retailer.
- We allow retailer's vertical relationships to vary across symmetric suppliers.
- The retailer may prefer the absence of a supply chain price leader to being a leader.

Asymmetric Relationships with Symmetric Suppliers: Strategic Choice of Supply Chain Price Leadership in a Competitive Market

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Abstract

This study investigates a supply chain member's strategic choice between price leadership and price followership against each of its supply chain partners. In particular, our investigation focuses on whether a retailer ever has an incentive to have asymmetric price leadership types across multiple suppliers even in the absence of asymmetry across them in demand, cost, and competitive pricing behavior. By analyzing a game-theoretic model composed of two manufacturers and one common retailer, we show that the retailer does not always prefer price leadership over a manufacturer, and that the retailer's strategic choice over price leadership with one manufacturer depends upon its price leadership type with the competing manufacturer and the degree of product substitutability. Surprisingly, although the competing manufacturers are completely symmetric in demand and cost characteristics, if the retailer does not have price leadership over one manufacturer, it prefers being a price leader over the other manufacturer when the product substitutability is sufficiently low, resulting in an asymmetric price leadership despite no asymmetry between the manufacturers. On the other hand, higher degrees of product substitutability lead the retailer to choose not to seek price leadership against either manufacturer. In contrast, each manufacturer always finds it profitable to be a price leader over the retailer, regardless of product substitutability and the price leadership situation between the retailer and the competing manufacturer. These strategic choices over vertical price leadership reflect interesting interplays of product positioning, the supply chain members' pricing objectives, and their foresights of other supply chain members' pricing behavior.

Keywords: Supply Chain Management, Price Leadership, Game Theory

1. Introduction

Downstream members of a supply chain frequently purchase substitutable products from multiple vendors, and the management of the vertical relationships with upstream suppliers is a central concern in supply chain management. In particular, numerous previous studies demonstrate the significant impact of the price leadership structure in supply chains on firm performance and overall supply chain efficiency (Choi 1991 & 1996; Lee and Staelin 1997; Trivedi 1998; Edirisinghe et al. 2011). Choi and Fredj (2013) also analyzed the impact of supply chain price leadership structures in the context of a retailer managing its own store band, and show the difference that they make to the profitability of the retailer and the manufacturer. This stream of research extends to more recent studies, in which the strategic implications of supply chain price leadership are investigated for revenue sharing and wholesale pricing mechanisms (Pan et al. 2010), the performance of closed-loop supply chains (Choi et al. 2013), and a manufacturer's incentive for the utilization of the dual channel strategy (Xiao et al. 2014).

The above-mentioned studies reflect practitioners' increasing concern about establishing and maintaining the "right" relationships with suppliers in today's business environment. Empirical evidence indicates that the price leadership situations between a retailer and multiple suppliers can vary substantially in many product categories (Cotterill and Putsis 2001), and, therefore, it should be a major consideration in a firm's supplier selection decision, which is a crucial issue in managerial and operational aspects of supply chain management (Chai and Ngai 2015). For instance, retailers have the strategic options of entrusting the private label production either to leading national brand manufacturers (e.g., Kraft Heinz, Pillsbury, Ralston Foods, Coca-cola, Ralcorp, etc.) that use their excess production capacity or to medium and small sized firms that cover specific markets (Dunne and Narasimhan 1999; Bergès-Sennou 2006; PLMA 2015). Choosing a leading national brand manufacturer as the vendor is likely to have the advantage of a more efficient production process but the disadvantage of a lower bargaining position (Bergès-Sennou 2006). In contrast, the retailer can take supply chain leadership through a better bargaining position by selecting medium and small sized local companies. A retailer's decision on whether to carry a store brand also depends on its implications for the price leadership structure with the supply chain. Cotterill and Putsis's (2001) empirical study shows that, in the consumer packaged goods categories, national brand manufacturers are often price leaders over the retailer, but no such leadership is exercised by store brand suppliers. Furthermore, the introduction of store brands can modify the pattern of national brand suppliers' exercise of their price leadership (Chintagunta et al. 2002).

The widespread use of category captainship is another specific example of a retailer's conscious effort to influence supply chain price leadership structure in a product category. In this arrangement, retailers share relevant category data with selected suppliers to enable them to take supply chain price leadership (Kurtuluş and Toktay 2011). It is a well known fact that manufacturers compete aggressively for such a leadership position, recognizing it as an opportunity to increase their influence over retail decisions (Kurtuluş and Toktay 2004). Nevertheless, prior studies indicate that category captains are not always large suppliers, but small suppliers also frequently attain the status, which implies that channel captainship does not automatically result from the supplier's superior size and bargaining power, but also reflects retailers' strategic choices to shape the supply chain price leadership structures (Misra et al. 2009).

The above examples have two important messages. First, in most cases, the price leadership structure seems neither entirely under the control of any particular supply chain member nor completely beyond the firms' control. Thus, there exists a room for firms (retailers, in particular) to take certain strategic actions to shape the supply chain price leadership to its advantage. Consequently, understanding the profit impact of different price leadership structures is an important concern for supply chain members. In particular, supply chain members need from new strategic guidelines for a firm's optimal choice of vertical price leadership type with one supplier conditional on the price leadership types with other suppliers. Second, these examples and empirical findings show that the price leadership situations faced by a retailer are seldom symmetric across its suppliers in the same category. We acknowledge that such asymmetry in vertical price leadership structure can stem from varying degrees of bargaining power and managerial sophistication among the competing suppliers, as observed in the difference between well-known national brand manufacturers and private label suppliers. In fact, Edirisinghe et al. (2011) operationalize such an environment by analyzing a model of one manufacturer's *horizontal* price leadership over another manufacturer, and demonstrate that such an asymmetry *between competing suppliers* of partially substitutable products can lead to asymmetric *vertical* price leadership structure *across manufacturer-retailer pairs*. This naturally raises a question on whether some types of asymmetry among the suppliers (e.g., different demand/cost structures, bargaining power, or horizontal price leader-follower relationship) are necessary for a retailer to prefer an asymmetric price leadership structure with its competing suppliers.

In this paper, we address these two issues by analyzing a game theoretic model of supply chain. Our model analysis focuses on examining how a retailer's particular price leadership situation with one manufacturer affects the retailer's incentive toward price leadership over other competing manufacturers. This allows us to mimic the situation where the retailer may have to take price leadership types as given with some suppliers, but still has control over price leadership situation with other suppliers, as discussed above. Therefore, we can explore, for instance, whether the retailer has an incentive to pursue price leadership over one manufacturer, when it does not have price leadership over the other manufacturer. In addition, our model assumes *symmetric* manufacturers supplying partially substitutable products to the retailer, with neither a leader-follower relationship nor any demand or cost asymmetries between the manufacturers. In this way, we rule out the possibility of supplier asymmetry causing asymmetric vertical price leadership structure, and focus on uncovering whether there exists any inherent strategic force that incentivizes a retailer to choose to have asymmetric price leadership types across its suppliers. By considering varying degrees of product substitutability, we also examine the impact of competitive intensity at the supplier level on the strategic choice of price leadership type by the retailer as well as the manufacturers.

A considerable amount of research has recognized the substantial impact of price leadership on supply chain member profitability and overall supply chain efficiency (Moorthy and Fader 1990; Choi 1991; Lee and Staelin 1997; Trivedi 1998; Shi et al. 2013), highlighting its critical importance for scholars and practitioners. In particular, these studies consider manufacturer–retailer relationships in which the manufacturer is the price leader (i.e., the Manufacturer Stackelberg game, hereafter labeled “MS”), the retailer is the price leader (i.e., the Retailer Stackelberg (RS) game), or no price leader exists (i.e., the Vertical Nash (VN) game). By analyzing the three types of leadership games, the previous theoretical studies have shown that supply chain leadership confers benefits especially in the demand environment where a supply chain member’s best reaction to its partner’s margin increase is to reduce its margin(i.e., the vertical strategic substitutability (VSS) case). Through empirical studies (Cotterill and Putsis 2001; Sudhir 2001; Kuiper and Meulenberg 2004), these game-theoretic models, along with a few other variations, are found to reflect diverse types of manufacturer–retailer strategic pricing interactions that exist in the real world. The effect of these three types of games representing different supply chain power structures were also studied in terms of other strategic decisions, such as supply chain coordination mechanisms, store brand management, quality levels, cooperative advertising, etc. (e.g., Pan et al. 2010; SeyedEsfahani et al. 2011; Choi and Fredj 2013; Ma et al. 2013).

Despite their important contributions to supply chain price leadership literature, the previous studies typically assume that the price leadership situation between a manufacturer and a retailer is the same across different pairs of vertical supply chain members. Under this assumption, previous theoretical studies commonly find that the VN game is never the most preferred game by any individual member. Instead, Choi (1991) and Lee and Staelin (1997) show that a supply chain member finds it most profitable to either be a price leader or follow its supply chain partner’s price leadership, depending on the demand environment. In contrast, we explicitly acknowledge the possibility of varying power balance situations across different manufacturer-retailer pairs within the same product category. In this way, we extend the price leadership literature by developing and analyzing a model in which the retailer's choice to be a supply chain price leader or follower can vary across the different manufacturers.

One previous study that has explored supply chain structures under asymmetric price leadership scenarios is by Edirisinghe et al. (2011). They consider eight asymmetric price leadership structures when one manufacturer is a price leader over the other manufacturer. This power imbalance between the two competing manufacturers leads to asymmetric price leadership situations across manufacturer-retailer pairs. By doing so, they focus on the implications of channel power on the stability of supply chain structures and the second-mover's advantage from a manufacturer's point of view. In contrast, our main interest is in the retailer's strategic incentive for supply chain price leadership with symmetric suppliers by assuming no horizontal price leadership nor power imbalance between manufacturers. In this setting, we analyze nine possible price leadership scenarios, caused by the retailer's asymmetric vertical relationships, and demonstrate that contrary to the case of having price leadership over all manufacturers, having leadership over only some of them might not be always optimal for the retailer. In the process, we provide an important new insight that the variations of the retailer's incentive for price leadership can be driven by its incomplete foresight in the category management even without the asymmetric leadership situation at the manufacturer's level.

Our results show that, if the retailer is a price leader of one of the manufacturers (i.e., the RS game), the retailer is better off by also exercising price leadership over the other manufacturer. Similarly, manufacturers selling their products through a common retailer always find it profitable to be a price leader over the retailer (i.e., the MS game) regardless of the price leadership situation of the competing manufacturer. In contrast, a retailer that is not a price leader over one of the manufacturers (i.e., the VN game or the MS game) may not always prefer being a price leader over the other manufacturer, but, instead, may opt for the absence of a price leader (i.e., the VN game) depending on the degree of substitutability among competing products. This finding is counter to the results of previous studies and implies that even a powerful retailer with sufficient ability and sophistication to become a price leader to some manufacturers might sometimes find it more profitable to choose not to become a price leader. These strategic choices of the retailer reflect its effort to optimally manage retail margins and sales volumes of competing brands within a product category with varying degrees of foresight of manufacturers' channel pricing behavior.

The remainder of this paper is organized as follows. In the next section, we present our theoretical model, followed in the third section by the equilibrium results for the symmetric price leadership game scenario and the asymmetric price leadership game scenario. Next, the robustness of our results is discussed. Finally, we conclude by discussing the implications of our findings and the limitations of the model, and suggested future research directions.

2. Model

Our model of industry consists of three players—two manufacturers and one common retailer—similar to the model used in Choi (1991). The two manufacturers sell differentiated but partially substitutable products in a market. Each of the two manufacturers, indexed M1 and M2, supplies one product to the common retailer (R). To focus on the impact of asymmetric price leadership types between the two vertical manufacturer–retailer relationships on supply chain members' incentive for price leadership, we assume that two manufacturers are identical in all other aspects except for the supply chain price leadership situation.[1]

We derive demand functions from the representative consumer utility model used by many previous studies (e.g., Singh and Vives 1984; Häckner 2000; Choi and Coughlan 2006; Ingene and Parry 2007; Cai et al. 2012). The utility model is specified as $U = A_1q_1 + A_2q_2 - \frac{1}{2}(q_1^2 + q_2^2) - \gamma q_1q_2 - p_1q_1 - p_2q_2$, where q_i and p_i are the purchase quantity and price of product i (i=1, 2), and γ ($0 \leq \gamma < 1$) denotes product substitutability. As γ increases, products become more substitutable and the intensity of competition increases between the two manufacturers. γ also denotes the degree of horizontal differentiation among products (Häckner 2000). Thus, the products become less differentiated as γ increases. A_i represents the intrinsic quality of product i (Choi and Coughlan 2006), which is assumed to be equal for the two products ($A_1 = A_2 = A$).[2]

The representative consumer selects optimal quantities of the products to maximize her utility. The first-order conditions, $\partial U/\partial q_1 = 0$ and $\partial U/\partial q_2 = 0$, provide the following demand system:

$$D_1 = \frac{A}{1+\gamma} - \frac{1}{1-\gamma^2}p_1 + \frac{\gamma}{1-\gamma^2}p_2 \qquad (1)$$

[1] Although no consistent evidence exists from the extant literature on the major factors that explain unequal power among different manufacturers, as mentioned previously, conducting additional analysis and relaxing this assumption (e.g., assuming asymmetric manufacturers in various aspects such as size and cost efficiency) may offer extra valuable insights.

[2] We also analyzed numerically the case in which A1 is not equal to A2 (e.g., A1 < A2). Although such an analysis yields more complex results, we still found that if the retailer is not a price leader over one manufacturer, the VN game can be more profitable for the retailer's interaction with the other manufacturer depending on the degree of product substitutability (γ).

$$D_2 = \frac{A}{1+\gamma} - \frac{1}{1-\gamma^2} p_2 + \frac{\gamma}{1-\gamma^2} p_1, \qquad (2)$$

where D_i is the demand for product i. We assume $\gamma < 1$ to satisfy the second-order condition for utility maximization (Cai et al. 2012). The above demand functions, derived from an underlying utility model of consumer demand, imply that the degree of product substitution(γ) affects not only the own-price sensitivity ($\frac{1}{1-\gamma^2}$) but also the base demand of product ($\frac{A}{1+\gamma}$). These features (i.e., the positive effect of product substitutability on the own-price sensitivity and its negative effect on the base demand) provide a clear linkage between the demand parameter and underlying market characteristics (Staelin and Lee 2014).[3] It is intuitively obvious that consumers become more price sensitive when comparing more substitutable products and less substitutable (more differentiated) products reach more consumers in the market (Cai et al 2012). These more realistic assumptions are particularly desired in our study because the product substitutability is one of the major factors driving main results of this study. Note that these demand functions are linear in price, offering superior mathematical tractability. The linearity of the demand function also implies vertical strategic substitutability (VSS), as shown by Lee and Staelin (1997).

Manufacturers' production costs are normalized to zero for mathematical simplicity. These demand and cost assumptions lead to the following objective functions for manufacturers and the retailer:

$$\max_{w_1} \Pi_{M1} = w_1 D_1, \qquad (3)$$

$$\max_{w_2} \Pi_{M2} = w_2 D_2, \qquad (4)$$

$$\max_{r_1, r_2} \Pi_{R} = r_1 D_1 + r_2 D_2, \qquad (5)$$

[3] To discuss the supply chain price leadership issues, the previous studies such as Edirisinghe et al. (2011) and Choi (1996) use the reduced-form demand function: $D_i = \mathrm{A} - \mathrm{B}p_i + \gamma(p_j - p_i)$, which can be rewritten as $D_i = \mathrm{A} - (\mathrm{B} + \gamma)p_i + \gamma p_j$. This demand function shares similarities with the representative consumer demand function qualitatively in that the product substitutability captured by γ has an effect on not only the cross-price sensitivity but also the own-price sensitivity. However, the main difference between two demand functions is that the product substitutability also affects the base demand of product (i.e., the intercept term) in the representative consumer demand function, which is not the case in the reduced form demand function.

where w_i and r_i (= $p_i - w_i$) represent the wholesale price and retail margin of product i, respectively. In this study, it is assumed that the price leadership situation in the retailer's relationship with one manufacturer can differ from that of its relationship with the other manufacturer.

Next, we solve this system of equations under various game rules to derive equilibrium results for different price leadership scenarios. Specifically, the three possible price leadership games (manufacturer Stackelberg [MS], retailer Stackelberg [RS], or vertical Nash [VN]) between each manufacturer and the common retailer, lead to nine possible scenarios that require analysis. Three of them are symmetric and the other six are asymmetric. The rules of the three symmetric price leadership game scenarios (MS/MS: both manufacturers are the price leader over the retailer, VN/VN: no price leader exists in both supply chains, RS/RS: the retailer is the price leader over both manufacturers) are the same as those used by Choi (1991) or Lee and Staelin (1997). Thus, the derivation of equilibrium solutions for these scenarios is straightforward. In addition, this study analyzes the asymmetric price leadership scenarios. The game rules of those asymmetric price leadership scenarios are as follows:[4] 1) *MS/VN (or VN/MS)*: M1 (M2) chooses a wholesale price using its foresight of the retailer's reactions for all products conditional on the wholesale price of M2 (M1). In contrast, M2 (M1) chooses a wholesale price conditional on both the retailer's margin on its own product and the retail price of the other product. Given these wholesale prices, the retailer determines retail margins of all products to maximize its category profit. 2) *RS/VN (or VN/RS)*: The retailer chooses retail margins on both products using its foresight of M1's (M2's) reaction conditional on the wholesale price of M2 (M1). M2 (M1) chooses a wholesale price conditional on the retail margin on its own product and the retail price of M1's (M2's) product. Given the retail margin on its own product and the retail price of the other product, M1 (M2) sets the wholesale price to maximize its own profit. 3) *MS/RS (or RS/MS)*: M1 (M2) chooses a wholesale price using its foresight of the retailer's reactions for all products. Given the wholesale price of M1 (M2), the retailer chooses retail margins on both products using the foresight of M2's (M1's) reaction. Given the retail margin on its own product and the retail price of the other product, M2 (M1) determines the wholesale price to maximize its own profit. This scenario was also analyzed by Edirisinghe et al. (2011).

Note that the competition between the two manufacturers is assumed a Bertrand-Nash game for all scenarios except MS/RS and RS/MS. For the MS/RS (or RS/MS) scenario, M1 (M2) considers

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[4] Please refer to the Technical Supplement A for the derivation of equilibrium prices for asymmetric price leadership scenarios.

the reaction function of the retailer—who is already using the foresight of M2's (M1's) reaction function—in its pricing decision for profit maximization. A logical consequence of these rules of the game is that M1 (M2) is the price leader over M2 (M1) as well as the retailer.

3. Analysis

3.1 Symmetric Price Leadership Game Scenario

As benchmark cases, we first consider the three symmetric price leadership game scenarios, in which the price leadership situation is the same between the two manufacturer–retailer pairs. The equilibrium solutions, presented in Table 1-A, indicate the following rank orders in price, margin, and profit for the manufacturers and the retailer. These rank orders are consistent with the results of previous studies by Choi (1991) and Lee and Staelin (1997):

1. Wholesale Price: $w_i^{MS/MS} > w_i^{VN/VN} > w_i^{RS/RS}$, i=1, 2;
2. Retail Price: $p_i^{MS/MS} = p_i^{RS/RS} > p_i^{VN/VN}$, i=1, 2;
3. Retail Margin: $r_i^{RS/RS} > r_i^{VN/VN} > r_i^{MS/MS}$, i=1, 2;
4. Manufacturers' Profit: $\Pi_{\mathrm{M1\ (or\ M2)}}^{MS/MS} > \Pi_{\mathrm{M1\ (or\ M2)}}^{VN/VN} > \Pi_{\mathrm{M1\ (or\ M2)}}^{RS/RS}$; and,
5. Retailer's Profit: $\Pi_{\mathrm{R}}^{RS/RS} > \Pi_{\mathrm{R}}^{VN/VN} > \Pi_{\mathrm{R}}^{MS/MS}$.

We note that manufacturers' wholesale prices are the same as their margins because of the zero cost assumption in our model. Consequently, we find that if the supply chain price leadership scenario is symmetric between the two competing manufacturers, each supply chain member earns the largest unit margin and the highest profit when it exercises price leadership. Therefore, supply chain members always prefer being a price leader in their vertical relationships.

(Table 1 about here)

3.2 Asymmetric Price Leadership Game Scenarios

Next, we examine the effect of supply chain price leadership choice on supply chain members' optimal prices and profits in the six asymmetric price leadership game scenarios. To simplify our exposition, we organized the discussion of this analysis by comparing the equilibrium results of different price leadership scenarios for M1 while holding fixed the price leadership scenario for M2 (i.e., MS/j, VN/j and RS/j, j = MS, VN, RS). Given the symmetry of demand and cost between M1 and M2, discussing the equilibrium solutions for three selected asymmetric price leadership game scenarios (MS/VN, RS/VN, and MS/RS), as presented in Table 1-B, is sufficient to cover all asymmetric price leadership games considered. The equilibrium solutions for other three asymmetric price leadership game scenarios (VN/MS, VN/RS, and RS/MS) can be obtained simply by switching indices 1 and 2 of the equilibrium solutions in Table 1-B.

3.2.1 Prices and Demands under Asymmetric Price Leadership

We first compare prices among different price leadership game scenarios and obtain the following results. First, when the retailer is the price follower (i.e., the MS game) in its relationship with M2, the equilibrium retail prices for both products are the highest if the retailer's relationship with M1 is the RS game and the lowest if the relationship with M1 is VN, for all values of γ. That is, $p_i^{RS/MS} > p_i^{MS/MS} > p_i^{VN/MS}$, i=1, 2. Second, when the retailer is the price leader (i.e., the RS game) over M2, the equilibrium retail prices are the highest in the MS game with M1, followed by the RS game, and then are lowest in the VN game, again regardless of the value of γ. That is, $p_i^{MS/RS} > p_i^{RS/RS} > p_i^{VN/RS}$, i=1, 2. Third, the same rank ordering holds when the retailer plays the VN game with M2 (i.e., $p_i^{MS/VN} = p_i^{RS/VN} > p_i^{VN/VN}$, i=1, 2). On the basis of these results, we develop the following lemma.

Lemma 1. The retail prices of product 1 and 2 are higher when a price leader exists in the retailer's relationship with M1 relative to that in the absence of the leader, i.e., $p_i^{MS/j} > p_i^{VN/j}$ and $p_i^{RS/j} > p_i^{VN/j}$, i=1, 2 and j = MS, VN, RS. (See Technical Supplement B for the proof.)

The result for p_1 in Lemma 1 is consistent with previous studies that found retail prices to be higher in the presence of the price leader than in its absence. Interestingly, Lemma 1 also indicates that the retail price of M2's product (p_2) follows the same rank ordering when the price leadership situation between R and M1 changes. We find this result to be intuitive in that a higher p_1 in the presence of the price leader for M1's vertical relationship allows p_2 to remain high without losing too much market share relative to the absence of price leadership between R and M1.

Lemma 2. The retail prices become higher when the retailer is a price leader in its interaction with one manufacturer but the price follower in the other relationship (i.e., MS/RS or RS/MS) than when it is either the price leader or the follower for both relationships (i.e., MS/MS or RS/RS). That is, $p_i^{RS/MS} > p_i^{MS/MS}$ or $p_i^{MS/RS} > p_i^{RS/RS}$, i=1, 2. (See Technical Supplement B for the proof.)

Under RS/MS (MS/RS), M2 (M1) is the price leader over not only the retailer but also M1 (M2). Thus, M2 (M1) increases its wholesale price[5] even higher than that in MS/MS or RS/RS by foreseeing both supply chain members' reactions, and the wholesale price increase raises the retail price. The higher retail price of M2's (M1's) product then increases the price of the competing product, resulting in $p_1^{RS/MS} > p_1^{MS/MS}$ ($p_2^{MS/RS} > p_2^{RS/RS}$).

Because our demand function assumes that a demand for a product decreases in its retail price, the total category demand is always the largest when M1 is in the VN game, holding fixed the price leadership situation for M2. Specifically, we find $D_{Total}^{VN/MS} > D_{Total}^{MS/MS} > D_{Total}^{RS/MS}$, $D_{Total}^{VN/RS} >$

[5] The relevant result for the wholesale price is further discussed in the next subsection.

$D_{Total}^{RS/RS} > D_{Total}^{MS/RS}$ and $D_{Total}^{VN/VN} > D_{Total}^{RS/VN} = D_{Total}^{MS/VN}$. By separately examining each product's demand, we find a similar result for the demand of M1 (D_1): $D_1^{VN/RS} > D_1^{RS/RS} > D_1^{MS/RS}$ and $D_1^{VN/VN} > D_1^{RS/VN} = D_1^{MS/VN}$. In contrast, when the retailer's relationship with M2 is MS, we find $D_1^{VN/MS} > D_1^{RS/MS} > D_1^{MS/MS}$ for most γ values, but we also find $D_1^{RS/MS} > D_1^{VN/MS}$ when γ is very high. The price of M1 must be lower than that of M2 under the RS/MS scenario because M2 is the price leader and M1 is the follower. Therefore, given the price asymmetry between two products under RS/MS, $D_1^{RS/MS}$ is larger than $D_1^{MS/MS}$. Furthermore, our analysis shows that the price gap $p_2 - p_1$ under RS/MS becomes larger than that under VN/MS when γ is very high. Consequently, $D_1^{RS/MS}$ is larger than $D_1^{VN/MS}$ when the products are highly substitutable, despite the fact that the price of M1 under RS/MS is highest among three scenarios (i.e., $p_1^{RS/MS} > p_1^{MS/MS} = p_2^{MS/MS} > p_1^{VN/MS}$). The results of D_1 are summarized as follows.

Lemma 3. M1 generally has the largest demand (D_1) in the absence of a price leader in its relationship with the retailer, regardless of the price leadership situation in the vertical relationship of M2. However, if M2 is a price leader over the retailer and γ is very high, D_1 is larger when M1 is a price follower (i.e., RS/MS) than that in the absence of the price leadership between M1 and the retailer (i.e., VN/MS). (See Technical Supplement B for the proof.)

In contrast, we find the opposite results for M2: $D_2^{MS/RS} > D_2^{RS/RS} > D_2^{VN/RS}$, $D_2^{MS/VN} = D_2^{RS/VN} > D_2^{VN/VN}$ and $D_2^{MS/MS} > D_2^{RS/MS}, D_2^{VN/MS}$, as seen in Figure 1.[6] These results indicate that having M1 as a price leader over the retailer always gives the largest demand to M2. Even the retailer as the leader over M1 (RS) generally offers M2 a larger demand than in the absence of the leader (VN). As previously shown, p_2 is higher in the MS or RS game for M1's vertical relationship than in the VN game. However, because p_1 also increases even more, the presence of the price leader in the competing supply chain provides M2 with a better demand.

Lemma 4. Regardless of the price leadership situation between M2 and R, the demand of M2 (D_2) is largest when M1 is a price leader over the retailer, whereas it is generally the smallest when neither M1 nor the retailer is a price leader. Only if M2 is a price leader over the retailer and γ is high, D_2 is larger when neither M1 nor the retailer is a price leader (i.e., VN/MS) than when M1 is a price follower (i.e., RS/MS).

(Figure 1 about here)

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[6] Although the results of all figures are obtained assuming A = 1, we find that all of the main results of this study are not affected by different A values.

3.2.2 Impact of Asymmetric Price Leadership on Competing Manufacturers

From the analysis of M1's equilibrium wholesale prices and profits, presented in Table 1, we find that regardless of the price leadership scenario of M2, M1's wholesale price and profit are the highest when M1 is in the MS game, followed by the VN game and then the RS game, for all values of γ. The numerical results are graphically summarized in Figure 2. These results are consistent with the results for the symmetric price leadership game scenarios presented in section 3.1. Thus, we find that, even under the asymmetry assumption, a manufacturer selling its product through a common retailer always prefers to be a price leader to the retailer, irrespective of the other competing manufacturer's price leadership situation.

Proposition 1. Regardless of the competing manufacturer(M2)'s price leadership situation, the rank orders in the M1's wholesale prices and profits for three price leadership scenarios are as follows:

$$w_1^{MS/j} > w_1^{VN/j} > w_1^{RS/j},$$

$$\Pi_{M1}^{MS/j} > \Pi_{M1}^{VN/j} > \Pi_{M1}^{RS/j}, \; j = \text{MS, VN, RS}.$$

(Figure 2 about here)

We also obtain interesting results that are new to the literature on the impact of M1's price leadership situation on M2's wholesale prices and profits. Specifically, if M2's interaction with the retailer is the MS game, M2's wholesale price and profit are highest when M1's vertical relationship is the RS game, followed by the MS game, and then the VN game (i.e., $w_2^{RS/MS} > w_2^{MS/MS} > w_2^{VN/MS}$ and $\Pi_{M2}^{RS/MS} > \Pi_{M2}^{MS/MS} > \Pi_{M2}^{VN/MS}$), regardless of γ. For the VN game for the relationship between M2 and the retailer, we find $w_2^{RS/VN} = w_2^{MS/VN} > w_2^{VN/VN}$ and $\Pi_{M2}^{RS/VN} = \Pi_{M2}^{MS/VN} > \Pi_{M2}^{VN/VN}$. Lastly, when the retailer plays the RS game with M2, we find $w_2^{MS/RS} > w_2^{RS/RS} > w_2^{VN/RS}$ and $\Pi_{M2}^{MS/RS} > \Pi_{M2}^{RS/RS} > \Pi_{M2}^{VN/RS}$. From these results depicted in Figure 3, we observe the following proposition.

Proposition 2. Regardless of the price leadership situation between M2 and the retailer, M2 prefers the existence of a price leader in the competing manufacturer(M1)'s vertical relationship with the retailer. That is, $\Pi_{M2}^{MS/j} > \Pi_{M2}^{VN/j}$ or $\Pi_{M2}^{RS/j} > \Pi_{M2}^{VN/j}$, j = MS, VN, RS.

(Figure 3 about here)

Lemma 1 shows that $p_1^{MS/j} > p_1^{VN/j}$ or $p_1^{RS/j} > p_1^{VN/j}$, j = MS, VN, RS. The M1's higher retail price in the presence of the price leader than in its absence for the M1's vertical relationship translates into weaker price competition from M2's perspective. Thus, M2 can increase its wholesale price more, which means an increase in margin, without altering its own supply chain price leadership situation when there is the price leader in the competing supply chain, i.e.,

$w_2^{MS/j} > w_2^{VN/j}$ or $w_2^{RS/j} > w_2^{VN/j}$, j = MS, VN, RS. In addition, M2 generally has a larger demand when a supply chain price leader is present in the M1's relationship with the retailer, as shown in Lemma 4. Although $D_2^{RS/MS}$ is smaller than $D_2^{VN/MS}$ if γ is high, as seen in Figure 1-A, Figure 3-A shows that M2 achieves the largest margin and, thus, the larger profit under RS/MS than under VN/MS or MS/MS. Consequently, M2's profit becomes always greater when a price leader exists in the competing supply chain than otherwise. Another interesting finding is that, depending on its own interaction with the retailer, M2 prefers either M1 or the retailer as a leader in the competing supply chain.

Proposition 3. When M2 is a price follower of the retailer, the competing manufacturer(M1)'s price leadership over the retailer is in M2's best interest (i.e., $\Pi_{\text{M2}}^{MS/RS} > \Pi_{\text{M2}}^{RS/RS}$). In contrast, the retailer's being a price leader over M1 is the most preferred scenario from M2's perspective when M2 is the price leader of the retailer (i.e., $\Pi_{\text{M2}}^{RS/MS} > \Pi_{\text{M2}}^{MS/MS}$).

M1's wholesale price is higher when M1 has price leadership than otherwise. Moreover, under MS/RS, M1 foresees all other supply chain members' reactions and, thus, even further increases its wholesale price, resulting in higher $p_1^{MS/RS}$ than not only $p_2^{MS/RS}$ but also $p_1^{RS/RS}$. Consequently, M2 is able to increase its wholesale price more under MS/RS than under RS/RS (i.e., $w_2^{MS/RS} > w_2^{RS/RS}$). It can also expand its market share given its competitive price (i.e., $p_2^{MS/RS} < p_1^{MS/RS}$), which leads to the first result in Proposition 3. In contrast, a different explanation is needed for the other result of Proposition 3: $\Pi_{\text{M2}}^{RS/MS} > \Pi_{\text{M2}}^{MS/MS}$. When M2 is the price leader over the retailer but M1 is the price follower (i.e., RS/MS), M2 instead foresees all other firms' reactions. Thus, the wholesale price of M2 (= M2's margin) becomes higher under RS/MS than when M1 is also the price leader over the retailer (i.e., $w_2^{RS/MS} > w_2^{MS/MS}$). However, as shown in section 3.2.1, $D_2^{MS/MS}$ is greater than $D_2^{RS/MS}$. Thus, the second result of the proposition implies that the advantage in the manufacturer margin of RS/MS over MS/MS outweighs the former's disadvantage in demand, which makes RS/MS more profitable for M2. Interestingly, Propositions 2 and 3 suggest that the manufacturer's profit is affected by not only its own price leadership situation but also that of the competing manufacturer.

3.2.3 Impact of Asymmetric Price Leadership on a Retailer's Pricing Strategy

When the retailer is a price leader (i.e., the RS game) over M2, the retail margin of product 1 (r_1) turns out to be highest in the RS game followed by the VN game, and then the MS game, i.e., $r_1^{RS/RS} > r_1^{VN/RS} > r_1^{MS/RS}$, irrespective of γ. In contrast, the retail margin of product 2 (r_2) is the same across different price leadership scenarios. It indicates that the variation of the price leadership situation in the retailer's relationship with M1 does not affect the retailer's margin decision for M2's product. The rank order of the retailer's profit is same as that of r_1, i.e., $\Pi_R^{RS/RS} > \Pi_R^{VN/RS} > \Pi_R^{MS/RS}$. This result indicates that the retailer, as a price leader over one manufacturer, is also better off taking over price leadership from the other competing manufacturer.

Proposition 4. When the retailer is a price leader over one manufacturer (M2), the retailer always achieves the largest profit by being a price leader, the second largest profit in the absence of a price leader, and the least profit by being a price follower in the relationship with the other manufacturer (M1), i.e., $\Pi_R^{RS/RS} > \Pi_R^{VN/RS} > \Pi_R^{MS/RS}$. (See Technical Supplement B for the proof.)

Lee and Staelin (1997) note that being a price leader has a positive effect on the retailer's margin but a negative effect on demand in the vertical strategic substitutability (VSS) environment when the price leadership situation is symmetric between the retailer's relationships with two manufacturers. Because the positive effect of price on margin dominates its negative effect on demand, being a price leader always results in higher retailer profits. Thus, if the retailer's interaction with one of the manufacturers is the RS game, the margin increase achieved by exercising price leadership over the other manufacturer dominates its negative effect on demand, making price leadership profitable for the retailer.

Even when the retailer has no foresight (i.e., the VN game or the MS game) in its interaction with M2, we find that the rank order of r_1 is the same as the case in which the retailer's interaction with M2 is the RS game, i.e., $r_1^{RS/j} > r_1^{VN/j} > r_1^{MS/j}$, *j*=VN, MS. However, the results change significantly for r_2. Specifically, if the retailer's relationship with M2 is the VN game, the retail margin r_2 under the RS/VN scenario is equal to that under the MS/VN scenario but also is smaller than the retail margin under the VN/VN scenario, i.e., $r_2^{VN/VN} > r_2^{RS/VN} = r_2^{MS/VN}$. For the MS game for the retailer's relationship with M2, we find that $r_2^{VN/MS} > r_2^{MS/MS} > r_2^{RS/MS}$. These rank orders of r_2 are shown in Figure 4. From the results, we observe the following lemma.

Lemma 5. a) If the retailer is not a price leader over M2, the retail margin of product 2 (r_2) is greater when no price leader exists in the other supply chain with M1 than when a price leader exists, i.e., $r_2^{VN/j} > r_2^{RS/j}$ and $r_2^{VN/j} > r_2^{MS/j}$, *j*=VN, MS. b) If the retailer is a price follower of M2, r_2 is the smallest when the retailer exercises price leadership in the relationship with M1 (i.e., RS/MS).

As in section 3.2.2, M2's wholesale price is higher in the presence of the price leader than in its absence for M1's vertical relationship, i.e., $w_2^{MS/j} > w_2^{VN/j}$ or $w_2^{RS/j} > w_2^{VN/j}$, *j* = MS, VN, RS. Consequently, under the VN or MS game with M2, the retailer lowers its margin for product 2 (r_2) to accommodate the higher wholesale price when a price leader is involved in the interaction with

M1 compared with the situation with no price leadership. Note that this result contrasts with the case of the RS game between M2 and the retailer, under which the price leadership between the retailer and M1 has no effect on r_2. This phenomenon occurs because the retailer's price leadership in the RS game comes with the foresight of M2's "accommodating" pricing behavior (i.e., reducing the wholesale price in response to the increase in the retail margin), which helps the retailer understand that she does not have to set r_2 too low.

(Figure 4 about here)

If the retailer interacts with M2 in the MS game but with M1 in the RS game, M2 takes advantage of its foresight of the retailer's stronger price sensitivity and M1's reaction. Thus, its wholesale price (w_2) becomes the largest among three price leadership scenarios for M1's vertical relationship. Moreover, the retail margin of product 2 (r_2) decreases to lower than that under the MS/MS scenario, leading to the second result (b) of Lemma 5.

Finally, and perhaps most interestingly, we find that being a price leader is not always in the best interest of the retailer. Specifically, as shown in Figure 5-A, when the retailer interacts with M2 in the MS game, the VN game become more profitable for the retailer's relationship with M1 as γ increases. That is, $\Pi_{\mathrm{R}}^{RS/MS} > \Pi_{\mathrm{R}}^{VN/MS} > \Pi_{\mathrm{R}}^{MS/MS}$ when γ is low, whereas $\Pi_{\mathrm{R}}^{VN/MS} > \Pi_{\mathrm{R}}^{RS/MS} > \Pi_{\mathrm{R}}^{MS/MS}$ when γ is moderate or high. Figure 5-B also shows that, if the level of substitutability between products (γ) is low, then $\Pi_{\mathrm{R}}^{RS/VN} > \Pi_{\mathrm{R}}^{VN/VN} > \Pi_{\mathrm{R}}^{MS/VN}$, but $\Pi_{\mathrm{R}}^{VN/VN} > \Pi_{\mathrm{R}}^{RS/VN} > \Pi_{\mathrm{R}}^{MS/VN}$ when γ becomes high. These results are summarized in the following proposition.

Proposition 5. a) When the retailer is a price follower of M2, the retailer finds it most profitable to have no price leadership (i.e., VN) with M1 at moderate or high levels of product substitutability. b) When the retailer interacts with M2 in the VN game, the absence of the price leader is the most profitable game scenario for the retailer's relationship with M1 if the two products sold by the retailer are highly substitutable.

(Figure 5 about here)

Our results for Proposition 5 contrast sharply with those of previous studies (e.g., Choi 1991; Lee and Staelin 1997) in which the VN game never becomes the most profitable price leadership scenario from the retailer's perspective when she interacts with manufacturers in the same type of price leadership scenario. Combined with the previous discussion of the results for the symmetric price leadership scenarios, this result indicates that the retailer clearly benefits from having price leadership over all manufacturers. However, having price leadership over a subset of manufacturers might actually be worse than having no price leadership at all.

Intuitively, these results can be explained as follows. As previously discussed, if the retailer has no price leadership over M2, the retail margin of product 2 (r_2) is smaller when the retailer interacts with M1 in the RS game than in the VN game (i.e., $r_2^{RS/j} < r_2^{VN/j}$, j=MS, VN). On the contrary, the opposite rank order is found for the retail margin from M1 (r_1). In the previous subsection, switching the game with M1 from VN to RS has been shown to increase the retail price of product 1 (p_1) when the retailer plays the VN game with M2, leading to decreased demand for product 1 (D_1) and increased demand for product 2 (D_2). The directions of these individual effects are summarized in Table 2. Thus, from the retailer's point of view, whether to change the game with M1 from VN to RS depends on the magnitude of the resulting demand shift from product 1 (with a higher retail margin) to product 2 (with a lower retail margin). Not surprisingly, our result in Proposition 5-a indicates that such a strategy switch is profitable for the retailer when γ is low because low product substitutability keeps the demand shift at a minimal despite the price advantage of product 2. However, the decrease in demand for product 1 (which is more profitable than product 2 on a per unit basis) is too significant to make RS more profitable than VN for the retailer in its relationship with M1 if the two products are sufficiently substitutable (i.e., γ is sufficiently high).

(Table 2 about here)

If the retailer plays the MS game with M2, similar changes in retail margins and demand are expected, as shown in Table 2, when the retailer changes its game with M1 from VN to RS. Thus, even if p_1 increases from the retailer taking over price leadership from M1, M2 experiences only a limited benefit (i.e., a minimal increase in D_2). Thus, the decrease in r_2 hurts the retailer's profit more than it benefits from the increase in D_2 when $\gamma > .39$, as depicted in Figure 5-A. Interestingly, in this parameter range, the retailer's best interest is perfectly aligned with the consumer's best interest because the absence of price leadership with M1 not only leads to higher retailer profits but also to lower retail prices for consumers.

3.3 Robustness check of the main results under the VSS environment

All of the results presented in the previous sections are derived from a demand model that is linear in prices. As discussed previously, such demand functions imply the vertical strategic substitutability (VSS) property (Lee and Staelin 1997). We acknowledge that VSS may not be the only possible type of vertical strategic interaction in a manufacturer–retailer relationship. However, it still seems more likely to be observed in the real world than other types given the strong interest that manufacturers and retailers exhibit in taking price leadership and its implication of the negative impact of a unit cost increase on unit margin for a supply chain member. In that sense, although our model was intentionally set up to favor price leadership optimality, we still found interesting cases in which exercising price leadership is not profitable for the retailer.

To ensure that our findings are not driven by peculiar properties of the chosen demand model, but instead represent robust results under the general condition of VSS, we analyzed the same model using another demand function also known to have the VSS property—the linear-multiplicative demand function presented by Lee and Staelin (1997), $D_i = (a - bp_i)p_j^{\gamma}$. γ also denotes the degree of product substitutability. As is shown in Figure 6-A, we once again find that the VN/VN scenario becomes more profitable for the retailer than the RS/VN scenario when products become more substitutable (i.e., as γ is high), as is true with the linear demand model. Similarly, the rank order of the retail margin in Figure 6-B (i.e., $r_1^{RS/VN} > r_1^{VN/VN} = r_2^{VN/VN} > r_2^{RS/VN}$) is also consistent with a retailer's asymmetric pricing decision for different manufacturers obtained under the linear demand case.

(Figure 6 about here)

4. Conclusion

This paper extends the literature on supply chain price leadership by analyzing supply chain structures in which the price leadership scenario is not same across multiple retailer–manufacturer pairs in the supply chain system. Without allowing for such an asymmetry, most prior research consistently reports that, from every supply chain member's perspective, the presence of a supply chain price leader is always desirable and a supply chain member is always better off by exercising price leadership in a market characterized by vertical strategic substitutability. In contrast, this study notes that the retailer's asymmetric vertical relationships can result from the retailer's strategic decisions, and allows it to establish different types of price leadership situations across multiple manufacturers. Unlike a previous study of asymmetric vertical price leadership structures (Edirisinghe et al. 2011), we eliminate any asymmetry between the competing suppliers, and demonstrate that an asymmetric price leadership structure can still emerge in a supply chain due to a strategic choice of the retailer.

Specifically, our analysis shows that a retailer, who has price leadership over one manufacturer, always has an incentive either to take away the other manufacturer's price leadership or to become a price leader. However, if the retailer is not a price leader over one of the manufacturers, it may prefer having no price leader in its relationship with the other manufacturer. Our analysis also shows that the each of the competing manufacturers always prefers being a price leader to the retailer regardless of the type of price leadership faced by the other competing manufacturer. These results indicate that complete price leadership over all other supply chain members is profitable; however, partial price leadership over a subset of supply chain members might sometimes be less profitable than no price leadership at all. This occurs because pricing decisions made with incomplete foresight of supply chain partners' pricing behavior are not guaranteed to be more optimal than those made with little foresight. Lee and Staelin (1997) also find that exercising price leadership can be suboptimal under the vertical strategic complementarity (VSC) condition. In contrast, this study shows that supply chain members can be better off in the absence of a price leader even in a market with the VSS property. At a broad level, however, both their study and ours point to the similar theme that decisions made with partial foresight of other supply chain members' behavior can be riskier than those made with no foresight.

Our findings have interesting implications for professionals and scholars in supply chain management. First, they suggest that the category manager must not handle the issue of supply chain price leadership as a relationship-specific decision because her price leadership decision for one supply chain partner affects her margin from another partner and, thus, her total aggregate profits. Instead, the manager must pay close attention to all firms' supply chain relations as a whole, and should understand how any strategic choice in one supplier relationship is interrelated with other relationships. Thus, in many of the retailer's important strategic decisions such as private label vendor selection, the manager needs to take into account not only the required selection criteria such as sales strength and cost efficiency of potential suppliers but also the effect of supply chain price leadership on the firm's total category profits.

Our results also suggest that price leadership is not always most desirable for retailers to pursue even in the market with the VSS property. If the retailer is not a price leader over one of the manufacturers in a product category, the retail manager is advised to pay close attention to the level of substitutability (or differentiation) among the products. Because a high level of product substitutability magnifies the interdependence of one supply chain relationship on another, choosing not to be a price leader might sometimes be wise even if one has the managerial ability and economic power to become a leader. Thus, for instance, when the retailer is not a price leader over an existing national brand manufacturer in less differentiated product categories, selecting another national brand manufacturer, with whom the retailer has balanced power, as a private label supplier might be more profitable. However, the retailer having supply chain leadership against the present manufacturer would be best off by pursing leadership over the private label supplier.

Lastly, this study might provide an alternative explanation for the prevalence of the VN games detected in previous empirical studies. For instance, Cotterill and Putsis (2001) found that in 10 out of 12 manufacturer-retailer relationships in 6 product categories, VN was the price leadership type. Although the growth of retail power may be one of the major factors that contributes to the prevalence of the VN game (Besanko et al. 1998), our results suggest that even powerful retailers, who are capable of taking over price leadership from some (but not all) manufacturers, may find it more profitable to play the VN game (which a manufacturer prefers over the RS game) rather than the RS game under certain conditions. As the marketplace continues to become more competitive with a larger number of competing brands with less differentiation, an increasing number of firms may strategically choose not to become active supply chain price leaders.

As previously acknowledged, our findings are obtained under the VSS assumption. Thus, it remains unclear whether and how much our results can be generalized to other types of vertical strategic interactions, such as vertical strategic complementarity (VSC) and vertical strategic independence (VSI) (Lee and Staelin 1997). However, under the VSI environment, channel margins and demand do not vary across different price leadership game scenarios (Lee and Staelin 1997). Thus, the VSI environment does not seem to be an interesting setting for future extensions of our study. In contrast, analyzing our model under the VSC environment might produce different results. Interestingly, however, a unique profit maximizing solution cannot be obtained from the analysis of the multiplicative demand function (e.g., $q_i = ap_i^{-\mathrm{b}}p_j^{\delta}$), leading to VSC because an examination of the shape of a retailer's objective function reveals that the retailer can earn profits infinitely by charging an infinite price (Choi 1991). Thus, Choi (1991) assumes symmetric prices to obtain results. However, the use of the multiplicative demand function is not appropriate for our purpose because a study of the asymmetric price leadership situation requires supply chain members to be able to make asymmetric pricing decisions for different products; thus, symmetric prices cannot be assumed if complete results are to be obtained. Of course, whether or not VSS is more prevalent than VSC in the real world remains an empirical question. Finally, we acknowledge that our analysis considered supply chain structures composed of one retailer and multiple manufacturers. However, the analysis did not consider the more typical case of multiple competing members at both levels. Although we believe that our main insights will not be significantly affected in such an extended model, further research needs to investigate how the increased complexity in supply chain structure affects a supply chain member's strategic choice of price leadership.

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Table 1. Equilibrium Results of Different Price Leadership Game Scenarios

A. Symmetric Price Leadership Game Scenarios

	MS/MS	VN/VN	RS/RS
w_1^*	$\frac{A(1-\gamma)}{2-\gamma}$	$\frac{A(1-\gamma)}{3-\gamma}$	$\frac{A(1-\gamma)}{2(2-\gamma)}$
w_2^*	$\frac{A(1-\gamma)}{2-\gamma}$	$\frac{A(1-\gamma)}{3-\gamma}$	$\frac{A(1-\gamma)}{2(2-\gamma)}$
r_1^*	$\frac{A}{4-2\gamma}$	$\frac{A}{3-\gamma}$	$\frac{A}{2}$
r_2^*	$\frac{A}{4-2\gamma}$	$\frac{A}{3-\gamma}$	$\frac{A}{2}$
D_1^*	$\frac{A}{4+2\gamma-2\gamma^2}$	$\frac{A}{3+2\gamma-\gamma^2}$	$\frac{A}{4+2\gamma-2\gamma^2}$
D_2^*	$\frac{A}{4+2\gamma-2\gamma^2}$	$\frac{A}{3+2\gamma-\gamma^2}$	$\frac{A}{4+2\gamma-2\gamma^2}$
Π_{M1}^*	$\frac{A^2(1-\gamma)}{2(2-\gamma)^2(1+\gamma)}$	$\frac{A^2(1-\gamma)}{(3-\gamma)^2(1+\gamma)}$	$\frac{A^2(1-\gamma)}{4(2-\gamma)^2(1+\gamma)}$
Π_{M2}^*	$\frac{A^2(1-\gamma)}{2(2-\gamma)^2(1+\gamma)}$	$\frac{A^2(1-\gamma)}{(3-\gamma)^2(1+\gamma)}$	$\frac{A^2(1-\gamma)}{4(2-\gamma)^2(1+\gamma)}$
Π_{R}^*	$\frac{A^2}{2(2-\gamma)^2(1+\gamma)}$	$\frac{2A^2}{(3-\gamma)^2(1+\gamma)}$	$\frac{A^2}{4+2\gamma-2\gamma^2}$

B. Asymmetric Price Leadership Game Scenarios

	MS/VN	RS/VN	MS/RS
w_1^*	$\frac{A(1-\gamma)(3+\gamma)}{6-\gamma^2}$	$\frac{A(1-\gamma)(3+\gamma)}{2(6-\gamma^2)}$	$\frac{A(1-\gamma)(2+\gamma)}{2(2-\gamma^2)}$
w_2^*	$\frac{A(1-\gamma)(2+\gamma)}{6-\gamma^2}$	$\frac{A(1-\gamma)(2+\gamma)}{6-\gamma^2}$	$\frac{A(1-\gamma)(4+2\gamma-\gamma^2)}{8(2-\gamma^2)}$
r_1^*	$\frac{A(3+2\gamma)}{2(6-\gamma^2)}$	$\frac{A}{2}$	$\frac{A(2-\gamma)(1+\gamma)}{4(2-\gamma^2)}$
r_2^*	$\frac{A(4+\gamma)}{2(6-\gamma^2)}$	$\frac{A(4+\gamma)}{2(6-\gamma^2)}$	$\frac{A}{2}$
D_1^*	$\frac{A(3+\gamma)}{2(1+\gamma)(6-\gamma^2)}$	$\frac{A(3+\gamma)}{2(1+\gamma)(6-\gamma^2)}$	$\frac{A(2+\gamma)}{8(1+\gamma)}$
D_2^*	$\frac{A(2+\gamma)}{6+6\gamma-\gamma^2-\gamma^3}$	$\frac{A(2+\gamma)}{6+6\gamma-\gamma^2-\gamma^3}$	$\frac{A(4+2\gamma-\gamma^2)}{8(2+2\gamma-\gamma^2-\gamma^3)}$
Π_{M1}^*	$\frac{A^2(1-\gamma)(3+\gamma)^2}{2(1+\gamma)(6-\gamma^2)^2}$	$\frac{A^2(1-\gamma)(3+\gamma)^2}{4(1+\gamma)(6-\gamma^2)^2}$	$\frac{A^2(1-\gamma)(2+\gamma)^2}{16(1+\gamma)(2-\gamma^2)}$
Π_{M2}^*	$\frac{A^2(1-\gamma)(2+\gamma)^2}{(1+\gamma)(6-\gamma^2)^2}$	$\frac{A^2(1-\gamma)(2+\gamma)^2}{(1+\gamma)(6-\gamma^2)^2}$	$\frac{A^2(1-\gamma)(4+2\gamma-\gamma^2)^2}{64(1+\gamma)(2-\gamma^2)^2}$
Π_R^*	$\frac{A^2(25+21\gamma+4\gamma^2)}{4(1+\gamma)(6-\gamma^2)^2}$	$\frac{A^2(34+18\gamma-\gamma^2-\gamma^3)}{4(1+\gamma)(6-\gamma^2)^2}$	$\frac{A^2(12+8\gamma-3\gamma^2-\gamma^3)}{32(1+\gamma)(2-\gamma^2)}$

Table 2. Effect of Price Leadership on Retailer Profits

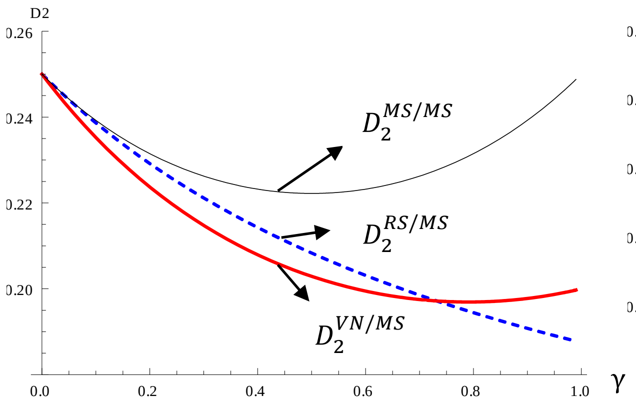
		VN/VN → RS/VN	VN/MS → RS/MS
Retail Margin	r_1	+	+
	r_2	−	−
Demand	D_1	−	Generally −*
	D_2	+	+ for $\gamma \le 0.732$. − for $\gamma > 0.732$.

* For γ >0.965, D_1 increases as VN/MS turns into RS/MS

Figure 1. Comparison of M2's demands: When the scenario for M2 is fixed (*A*=1).

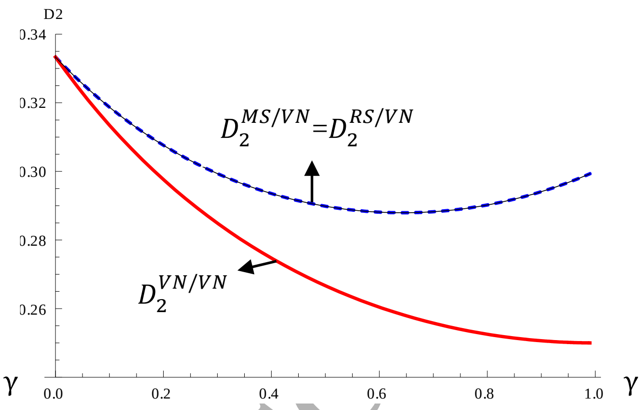
A. The relationship of M2 is MS.

M2's demand



B. The relationship of M2 is VN.

M2's demand



C. The relationship of M2 is RS.

M2's demand

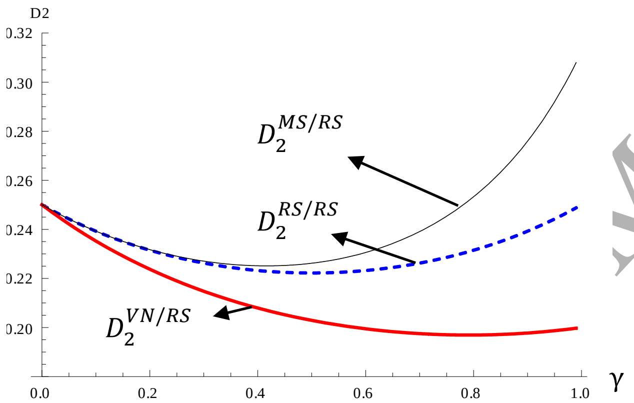
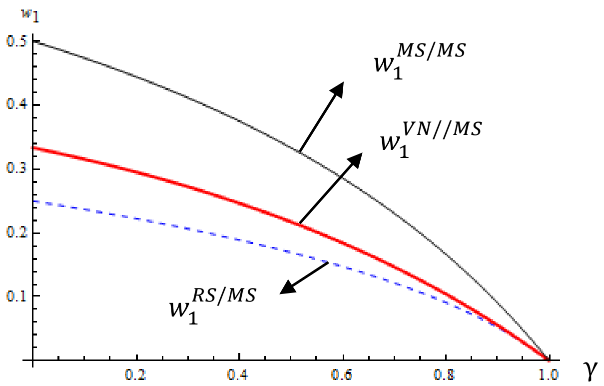


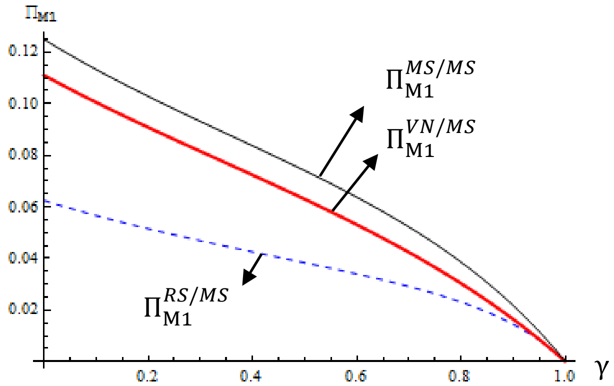
Figure 2. Comparison of M1's wholesale prices and profits: When the scenario for M2 is fixed.

A. The relationship of M2 is MS.

M1's wholesale price

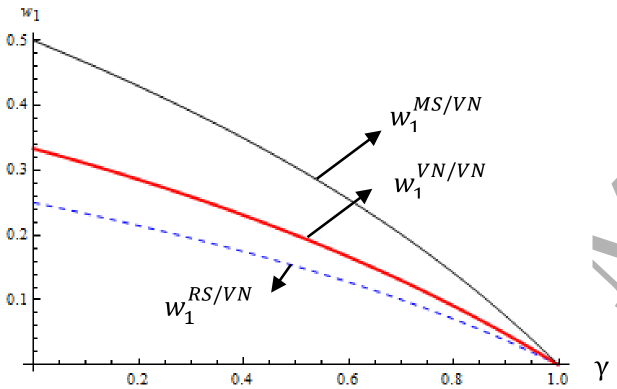


M1's profit

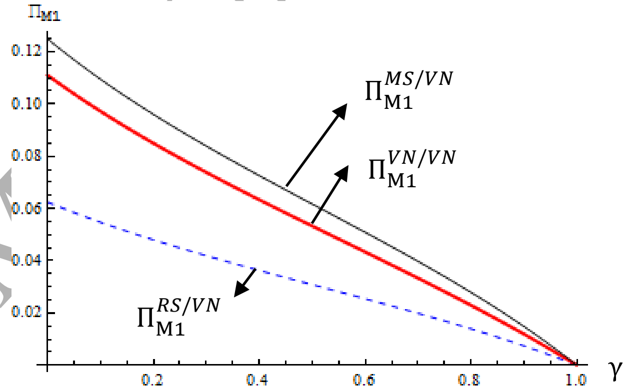


B. The relationship of M2 is VN.

M1's wholesale price

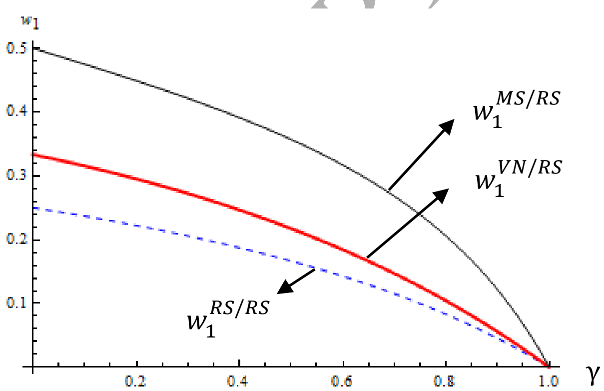


M1's profit



C. The relationship of M2 is RS.

M1's wholesale price



M1's profit

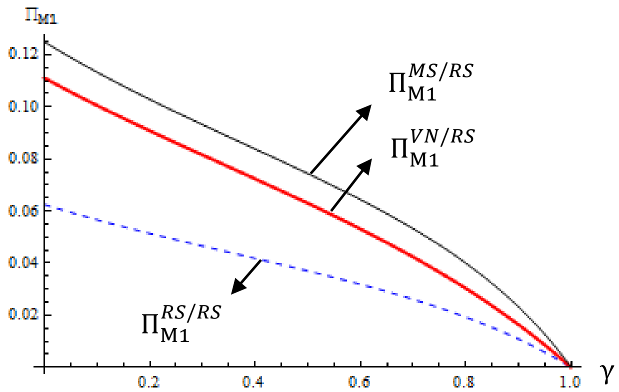
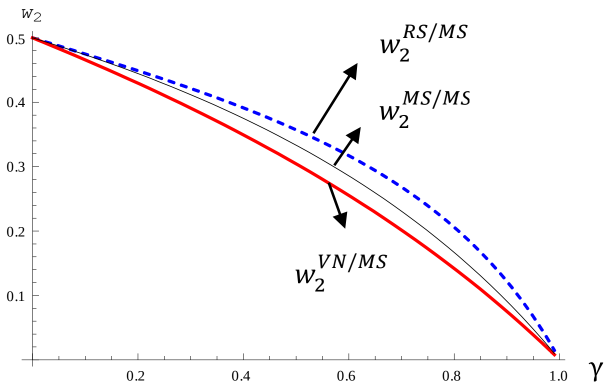


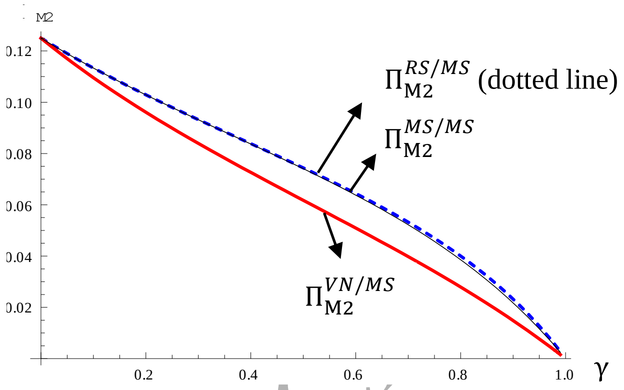
Figure 3. Comparison of M2's wholesale prices and profits: When the scenario for M2 is fixed.

D. The relationship of M2 is MS.

M2's wholesale price

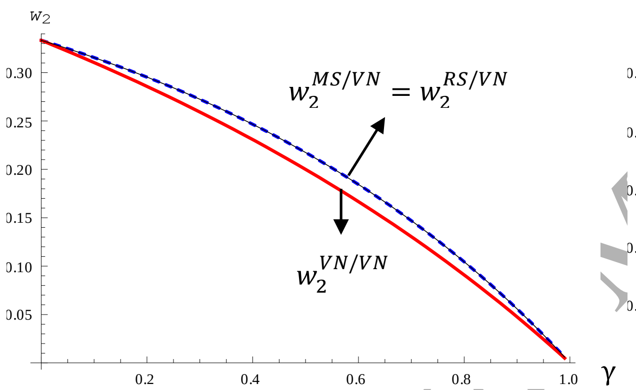


M2's profit

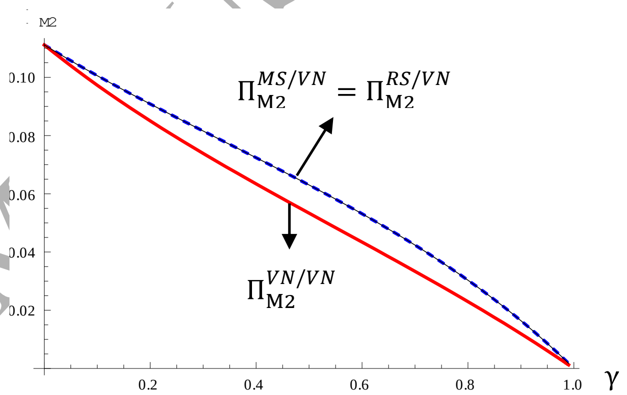


E. The relationship of M2 is VN.

M2's wholesale price

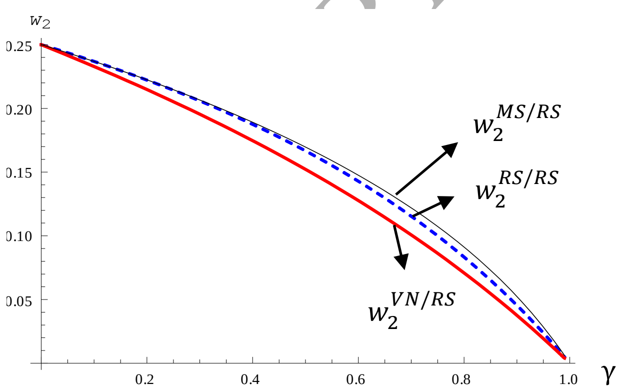


M2's profit



F. The relationship of M2 is RS.

M2's wholesale price



M2's profit

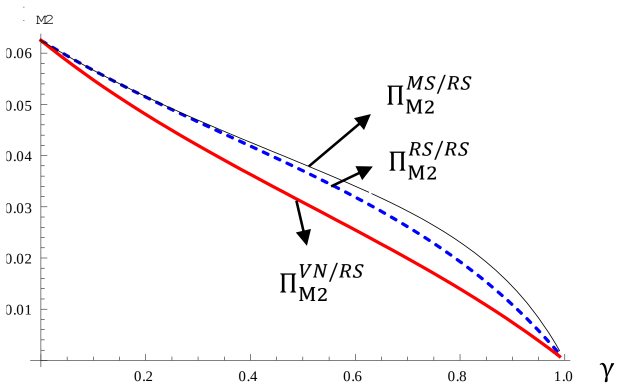


Figure 4. Comparison of retail margin r_2: When the scenario for M2 is fixed as MS or VN (A=1).

A. The relationship with M2 is MS. B. The relationship with M2 is VN.

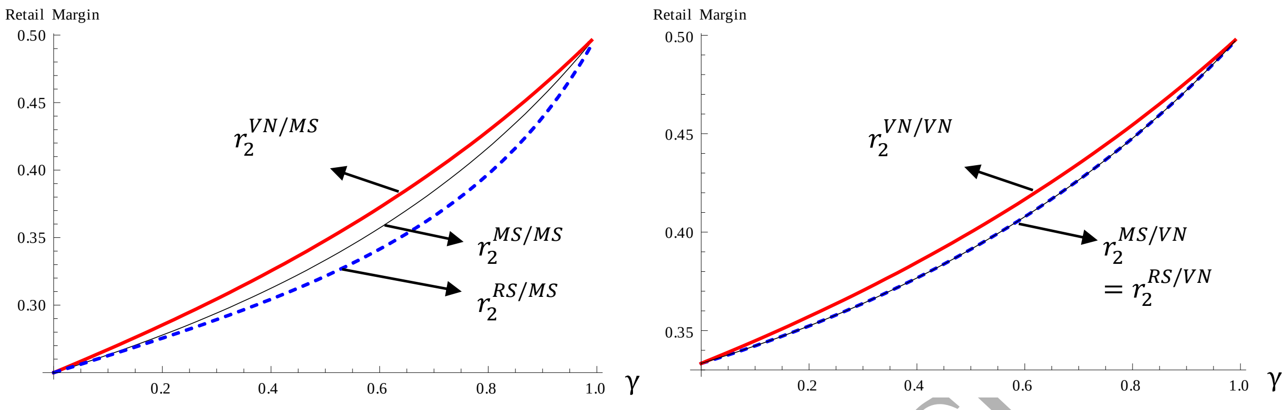


Figure 5. Retailer's profits: Among the different leadership scenarios for M1 when the scenario for M2 is fixed. (A=1)

A. The relationship with M2 is MS. B. The relationship with M2 is VN.

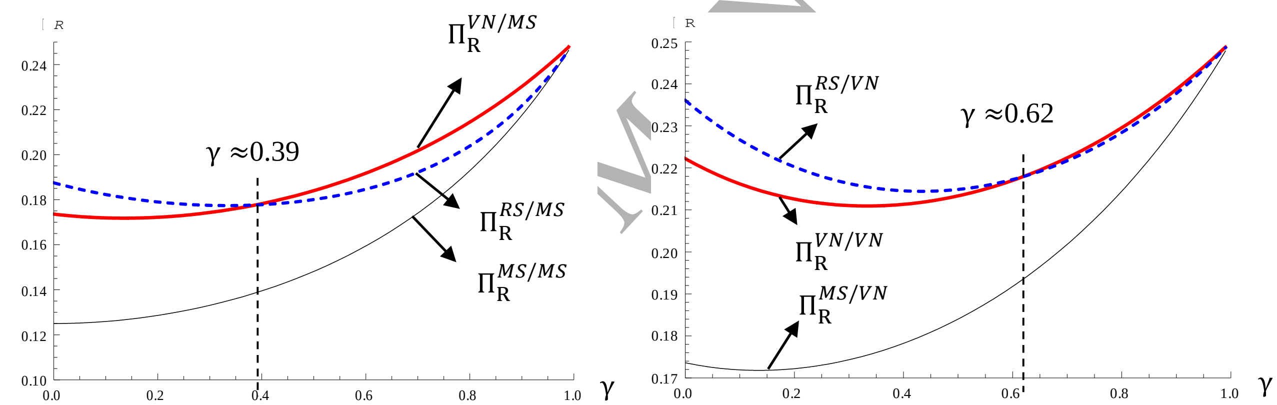


Figure 6. Results of the linear-multiplicative demand: Among the different leadership scenarios for M1 when the scenario for M2 is fixed as VN (***a*=1, *b*=1)**.

A. Retailer's Profit $\boldsymbol{\Pi_R}$ (Vertical axis). B. Retail Margins $\boldsymbol{r_i}$ (Vertical axis).