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Integrating Production Costs in Channel Decisions

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Abstract

Production costs are critical in every business. In this research, we explore how variations in the manufacturer's production cost affect both the manufacturer–retailer channel relationship and the manufacturer's and the retailer's choice of a price-setting rule (e.g., a dollar-amount margin or a percentage-based margin). We employ a multidisciplinary approach that combines executive interviews, survey research, and a game-theoretic analytical model. The analytical model shows that both the manufacturer's and the retailer's price-setting rule influences the other party's approach to production cost. Therefore, the manufacturer's and the retailer's optimal choice of a price-setting rule is not invariant, as previous marketing literature has suggested; such choices depend on the shape of the production cost function. Overall, the results offer new insight into the channel outcomes in light of production costs. The empirical results support the analytical results.

Keywords: Retailing; Channels; Pricing; Game-theory

Introduction

Production costs are critical in every business. In this research, we explore the impact of the manufacturer's production cost on the manufacturer's and the retailer's pricing decisions, as well as on the channel relationships. Marketing literature in channel relationship usually assumes that per-unit production costs are controlled by the manufacturers and set at a certain constant level. For example, Choi (1991, 1996), Lee and Staelin (1997), McGuire and Staelin (1983), Raju, Sethuraman, and Dhar (1995), Sayman and Raju (2004), and Tyagi (2005), among others, adopt a constant per-unit production cost, or a constant marginal production cost with no fixed cost. However, per-unit production costs are often increasing or decreasing functions of production volumes, due to economies or diseconomies of scale.

Ignoring such nonlinearity in the production cost function (variations in the shape of the cost function) may lead to a significant bias in the manufacturer's and the retailer's pricing decisions. For example, in prestudy interviews, we find that manufacturers with decreasing production cost are more willing to cut their wholesale prices than those with constant per-unit production cost. Few papers in the marketing literature account for nonlinearity in the manufacturer's cost function. We try to fill this gap in the literature.

Prior research in marketing has suggested that manufacturers and retailers often follow certain price-setting rules (see Choi 1991; Choi and Coughlan 2006; Draganska and Klapper 2007; Kopalle et al. 2009; Krishnan and Soni 1997; Lee and Staelin 1997; Mantrala, Basuroy, and Gajanan 2005). Having chosen the price-setting rule, they then optimize the variable under the price-setting rule. Manufacturers (retailers) typically use one of the three price-setting rules: (1) a rule based on setting the dollar-amount wholesale (retail) price, (2) a rule based on setting the dollar-amount manufacturer (retailer) margin, or (3) a rule based on setting the percentage manufacturer (retail) margin. For example, if the manufacturer chooses the price-setting rule based on setting the dollar-amount wholesale price, it will subsequently optimize the value of the wholesale price. If the manufacturer chooses the price-setting rule based on setting the dollar-amount manufacturer margin, it will optimize the value of the dollar-amount margin. Similarly, if the manufacturer opts for a rule based on setting the percentage manufacturer margin, it will optimize the value of the percentage margin. The prestudy interviews with executives and the surveys we conducted confirm the prevalence of these three price-setting rules.

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Table 1
Manufacturer's choice of price-setting rule.

Cost function	Manufacturer is Stackelberg leader		Retailer is Stackelberg leader		Manufacturer and retailer are Bertrand–Nash competitors	
	Tyagi (2005)	This paper	Tyagi (2005)	This paper	Tyagi (2005)	This paper
Constant	Indifferent	Indifferent	Indifferent	Indifferent	Indifferent	Indifferent
Increasing	N/A	Rule based on setting dollar-amount wholesale price	N/A	Indifferent	N/A	Rule based on setting dollar-amount wholesale price
Decreasing	N/A	Rule based on setting dollar-amount manufacturer margin if elasticity of cost function ≥ 1 Rule based on setting percentage manufacturer margin if elasticity of cost function <1	N/A	Indifferent	N/A	Rule based on setting dollar-amount manufacturer margin if elasticity of cost function ≥ 1 Rule based on setting percentage manufacturer margin if elasticity of cost function <1

Different price-setting rules may have different impacts on the manufacturer–retailer relationship. First, the manufacturer's and the retailer's choice of a price-setting rule affects the other party's pricing decision. Suppose that a shoe retailer follows the price-setting rule based on setting the dollar-amount retail margin. If the retailer requires a $30 retail margin on a pair of shoes whose wholesale price is $50, any change in the manufacturer's wholesale price will lead to the same amount of change in the retail price. However, if the retailer follows a price-setting rule based on setting the percentage retail margin and, based on such a rule, asks for a 60% retail margin on the wholesale price, the manufacturer will have to be extremely cautious in raising the wholesale price because an increase in the wholesale price will cause a 160% increase in the retail price.

Second, and this is what we explore in this research, price-setting rules define how the manufacturer and the retailer share concerns regarding the production cost. Intuitively, when a manufacturer asks for a dollar-amount manufacturer margin instead of a dollar-amount wholesale price, a variation in production cost will directly affect the retailer's profit but will not directly affect the manufacturer's profit. Therefore, when considering any variation in the production cost due to the economies or diseconomies of scale, the manufacturer's and the retailer's choice regarding the price-setting rule will have a significant impact on the channel results.

Tyagi (2005) uses a game-theoretical model to study the effects of price-setting rules on channel relationships. He considers three possible cases: (1) the manufacturer as a Stackelberg leader to the retailer, (2) the manufacturer as a Stackelberg follower to the retailer, and (3) the manufacturer and the retailer as Bertrand–Nash competitors. In all three cases, the manufacturer and the retailer choose their price-setting rules and set the optimal value of the pricing variable under the chosen rule. Without considering the production cost factor, Tyagi (2005) shows that manufacturers are always indifferent to price-setting rules and that the retailer, when it acts as a Stackelberg leader or a Bertrand–Nash competitor to the manufacturer, always prefers the rule based on setting a percentage retail margin.

We conducted a prestudy survey to test Tyagi's (2005) results and found that many manufacturers prefer margin-based price-setting rules and that some retailers adopt the rule based on setting a dollar-amount retail margin. To more thoroughly explore the role of the price-setting rules in channel relationship and firms' optimal choices regarding them, we extend Tyagi's (2005) model by introducing a variable production cost. The manufacturer's production cost function significantly affects both the manufacturer's profit and the retailer's profit and, consequently, their respective preferences regarding these price-setting rules. We make two key contributions and report three major findings. Tables 1 and 2 summarize these main findings.

Our first key contribution lies in understanding how a manufacturer's production cost function affects both the manufacturer's and the retailer's choice of a price-setting rule. We report three main analytical results. First, when the manufacturer is a Stackelberg follower, it is indifferent to the choice of the three price-setting rules. However, when the manufacturer is a Stackelberg leader or a Bertrand–Nash competitor to the retailer, its choice of a price-setting rule depends critically on the nature of the production cost function. If the per-unit production cost function is increasing because of diseconomies of scale, the manufacturer strictly prefers the rule based on setting a dollar-amount wholesale price as opposed to margin-based price-setting rules. If the per-unit production cost function is decreasing because of economies of scale, the manufacturer prefers the rule based on setting dollar-amount manufacturer margin as opposed to the rule based on setting a dollar-amount wholesale price. Intuitively, when the manufacturer follows a margin-based pricing rule rather than the rule based on setting a dollar-amount wholesale price, the retailer's cost is related to the per-unit production cost. Given an increasing production cost function, the retailer has an incentive to raise the retail price. Sales, per-unit production cost, and the wholesale price will then drop. The retailer can benefit from an increased retail margin, but the manufacturer will suffer from reduced sales. However, given a decreasing production cost function, the retailer's attempt to reduce production cost will lead to an increase in sales, which will benefit the manufacturer. Therefore, the manufacturer prefers to set a manufacturer margin when its production cost function is decreasing, but it prefers to set a dollar-amount wholesale price when its production cost function is increasing. Note that these results extend Tyagi's (2005) findings, in which the Stackelberg leader manufacturer is indifferent to the choice of a price-setting rule. Furthermore, if the per-unit cost function is decreasing and the elasticity of per-unit

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Table 2
Retailer's choice of price-setting rule.

Cost function	Manufacturer is Stackelberg leader		Retailer is Stackelberg leader		Manufacturer and retailer are Bertrand–Nash competitors	
	Tyagi (2005)	This paper	Tyagi (2005)	This paper	Tyagi (2005)	This paper
Constant	Indifferent	Indifferent	Rule based on setting percentage retail margin	Rule based on setting percentage retail margin	Rule based on setting percentage retail margin	Rule based on setting percentage retail margin
Increasing	N/A	Indifferent	N/A	Rule based on setting dollar-amount retail margin if elasticity of cost function > percentage manufacturer margin	N/A	Rule based on setting dollar-amount retail margin if elasticity of cost function > percentage manufacturer margin
Decreasing	N/A	Indifferent	N/A	Rule based on setting percentage retail margin; Otherwise, rule based on setting percentage retail margin if elasticity of cost function ≤ percentage manufacturer margin	N/A	Rule based on setting percentage retail margin; Otherwise, rule based on setting percentage retail margin if elasticity of cost function ≤ percentage manufacturer margin

production cost function is less than unity, the manufacturer prefers a percentage manufacturer margin.

Second, when the retailer is a Stackelberg follower, it is indifferent to the various price-setting rules. However, if the retailer is a Stackelberg leader or a Bertrand–Nash competitor to the manufacturer, it prefers the rule based on setting a percentage retail margin if the per-unit production cost is a decreasing function of production quantity or if the per-unit cost is an increasing function of production quantity and the elasticity of the cost function is less than the percentage manufacturer margin; otherwise, the retailer would rather choose the rule based on setting a dollar-amount retail margin. The logic is as follows: The retailer wants to choose a price-setting rule based on a percentage retail margin instead of a dollar-amount retail margin to incentivize the manufacturer to cut the wholesale price because the manufacturer faces a more elastic demand under the rule based on a percentage retail margin. However, the manufacturer will not cut the wholesale price if the production cost function is increasing and if its elasticity is larger than the manufacturer margin, because though a reduction in the wholesale price will benefit the manufacturer by increasing sales, it will induce a larger loss of the manufacturer's profit by the raising per-unit production cost. Therefore, under this condition, the retailer would choose the price-setting rule based on a dollar-amount retail margin. This result also extends Tyagi's (2005) solution of the Stackelberg leader retailer always choosing the percentage retail margin as the price-setting rule under constant marginal cost.

Third, if the manufacturer is a Stackelberg leader and the per-unit production cost is a decreasing function of production quantity, when the manufacturer switches its price-setting rule from a dollar-amount wholesale price to a dollar-amount manufacturer margin, the total channel profit increases.

Our second contribution is an empirical study of manufacturers and the factors that drive their choice of price-setting rules. We are yet to come across any empirical study of the drivers of price-setting rules in marketing. As such, our survey adds to the channels literature regarding the determinants of manufacturers' and retailers' price-setting rules. Our empirical results, based on survey data, show that when manufacturers have a nonincreasing cost structure, they prefer a margin-based price-setting rule. Conversely, when manufacturers have an increasing cost structure, they prefer a non-margin-based price-setting rule. These empirical results are in line with our theoretical findings.

We organize the rest of this paper as follows: In the next section, we discuss the prestudy interviews that we conducted among a small selected set of manufacturers and retailers. Then, we set up the basic analytical model. We then study three cases: (1) The manufacturer is a Stackelberg leader, (2) the retailer is a Stackelberg leader, and (3) the manufacturer and the retailer are Bertrand–Nash competitors. Then, we describe our empirical methodology and the results. We close with a discussion of the results.

Prestudy interviews

To ground our research in practice, we personally contacted 12 U.S. industry executives in manufacturing and retailing sec-

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tors by telephone. Our choice of companies was motivated by the desire to capture a broad spectrum of manufacturers and retailers across different types of industries (e.g., semiconductors, pharmaceuticals, food and beverage) and geographic locations (e.g., Maine, Texas). We asked these executives various questions to assess the nature of their per-unit production costs and the price-setting rules that they follow.

The responses in these telephone surveys indicated that manufacturers and retailers used all three types of price-setting rules (i.e., setting dollar-amount price, setting dollar-amount margins, and setting percentage margins) and also faced increasing or decreasing cost structures. In addition, the survey showed that both manufacturers and retailers are aware of each other's pricing strategies. On the basis of this prestudy, we contacted additional manufacturers and retailers by telephone to complete a Web-based survey. We describe the empirical results in detail subsequently.

Analytical model setup

We consider a simple analytical model in which a manufacturer sells a product through a retailer. The demand function is $q(p)$, where p is the retail price, which is known to both the manufacturer and the retailer. The manufacturer faces a per-unit production cost function $c(q)$, which may be an increasing function or a decreasing function, depending on whether the manufacturer has economies or diseconomies of scale. For example, if the manufacturer's fixed cost in production is significant or if it can take quantity discounts on the inputs' prices, the per-unit production cost decreases as production increases; if the manufacturer faces a capacity constraint, managerial inefficiency, overtime wages, or public and government opposition, the per-unit production cost may increase as production quantity increases. Thus, the shape of the cost function is a key factor in the model. We assume that the manufacturer's cost function is common knowledge in the distribution channel (i.e., the retailer knows the manufacturer's cost function) (see, e.g., Choi 1991).

The channel literature has pointed out several common formats for the manufacturer and the retailer to set their prices, as we discussed previously. Specifically, the manufacturer can choose one of the three price-setting rules: a dollar-amount wholesale price w; a dollar-amount manufacturer margin m, where $w = m + c$; or a percentage manufacturer margin α, where $w = (1 + \alpha) \cdot c$. The retailer can also choose one of the three price-setting rules: a dollar-amount retail price p; a dollar-amount retail margin r, where $p = w + r$; or a percentage retail margin β, where $p = (1 + \beta) \cdot w$.

Next, we describe the games for the three separate cases that we consider. In Case 1, the manufacturer acts as the Stackelberg leader to the retailer. In this game, the manufacturer first chooses one price-setting rule and optimizes the pricing variable under this rule to maximize its profit. Then, the retailer chooses its price-setting rule and optimizes the pricing variable to maximize its profit.

In Case 2, the retailer acts as the Stackelberg leader to the manufacturer. The retailer first chooses one price-setting rule and optimizes the pricing variable under this rule to maximize its profit. Then, the manufacturer chooses its price-setting rule and optimizes the pricing variable to maximize its profit.

In Case 3, the manufacturer and the retailer are Bertrand–Nash competitors. The manufacturer and the retailer act simultaneously. Each chooses one price-setting rule and optimizes the pricing variable under the chosen rule. In the market equilibrium, the manufacturer (retailer) anticipates that the retailer (manufacturer) adopts its optimal price-setting rule and sets the pricing variable at the optimal level.

Before we proceed, we state the following lemma:

Lemma 1. *A Stackelberg follower's choice of price-setting rules does not affect the equilibrium outcome.*

Lemma 1 is intuitive. If the retailer is the Stackelberg follower, regardless of what price-setting rule is chosen, only the resultant retail price affects the sale. Therefore, as a Stackelberg leader, the manufacturer is not affected by the retailer's choice of price-setting rule. Similarly, if the manufacturer is the Stackelberg follower, its choice of price-setting rules does not matter; only the resulting wholesale price affects the retailer's cost and, consequently, the quantity sold. As a Stackelberg leader, the retailer is not affected by the manufacturer's choice of a price-setting rule.

However, the Stackelberg leader's and the Bertrand–Nash competitor's choice of the price-setting rule affects the Stackelberg follower's and Bertrand–Nash competitor's optimal response and, consequently, the equilibrium outcomes. In the following three sections, we study the leader's optimal strategy regarding price-setting rules and pricing variables under the three cases.

Case 1. *The manufacturer is modeled as a Stackelberg leader.*

When the manufacturer is a Stackelberg leader, its price-setting rule affects the retailer's decision regarding the retail price. We use backward induction to analyze the equilibrium.

The retailer's profit-maximizing problem is $\pi_r = \max_p (p - w)q$. The first-order condition varies depending on the manufacturer's choice of the price-setting rules:

a. If the manufacturer adopts the price-setting rule based on setting a dollar-amount wholesale price w, the retailer solves the following:

$$\frac{\partial \pi_r}{\partial p} = q + (p - w)\frac{\partial q}{\partial p} = 0. \tag{1}$$

b. If the manufacturer adopts the price-setting rule based on setting a dollar-amount manufacturer margin m, and $w = m + c$, the retailer solves the following:

$$\frac{\partial \pi_r}{\partial p} = q\left(1 - \frac{\partial c}{\partial q}\frac{\partial q}{\partial p}\right) + (p - w)\frac{\partial q}{\partial p} = 0. \tag{2}$$

c. If the manufacturer adopts the price-setting rule based on setting a percentage manufacturer margin α, and $w = c(1 + \alpha)$, the retailer solves the following:

$$\frac{\partial \pi_r}{\partial p} = q\left(1 - (1 + \alpha)\frac{\partial c}{\partial q}\frac{\partial q}{\partial p}\right) + (p - w)\frac{\partial q}{\partial p} = 0. \tag{3}$$

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Note that if per-unit production cost is variable, or $\partial c/\partial q \neq 0$, the retailer's reaction functions change depending on the price-setting rule the manufacturer selects. Therefore, the manufacturer's optimal choice of price-setting rule is affected by its production cost function.

Lemma 2. *If a Stackelberg leader manufacturer's per-unit production cost is constant, the manufacturer is indifferent to the choice of a price-setting rule. If its per-unit production cost is not constant, the equilibrium outcomes are not invariant to its choice of the price-setting rule.*

If the manufacturer's per-unit production cost is constant, or $\partial c/\partial q = 0$, Eqs. (2) and (3) collapse to Eq. (1). Under this circumstance, the equilibrium outcomes are invariant to the price-setting rules the manufacturer selects. Recall that in this case, the retailer is modeled as a Stackelberg follower and, in accordance with Lemma 1, is also indifferent to the price-setting rule the manufacturer chooses. Therefore, we state the following corollary, which is essentially Proposition 1 in Tyagi (2005).

Corollary 1. *If a Stackelberg leader manufacturer's per-unit production cost is constant, the equilibrium outcomes are invariant to the price-setting rules that are assigned to the retailer and the manufacturer.*

When the manufacturer's per-unit cost function is not constant, its optimal price-setting rule depends on the structure of the production cost function. Specifically, Proposition 1 defines the condition under which the manufacturer chooses a price-setting rule based on setting a dollar-amount wholesale price instead of margin-based price-setting rules.

Proposition 1. *(a) A Stackelberg leader manufacturer prefers a price-setting rule based on a dollar-amount wholesale price as opposed to other rules if its per-unit production cost is a monotonically increasing function of quantity. (b) The manufacturer prefers a price-setting rule based on setting a dollar-amount manufacturer margin as opposed to one based on setting a dollar-amount wholesale price if its per-unit production cost is a monotonically decreasing function of the quantity.*

See Appendix A for the proof. The key difference between choosing a price-setting rule based on a dollar-amount wholesale price versus one based on manufacturer margin lies in whether the manufacturer wants to involve the retailer in the production cost decision process. When a manufacturer charges a dollar-amount wholesale price to its retailer, the production cost is irrelevant to the retailer. However, when the manufacturer picks a price-setting rule based on manufacturer margin, the retailer's cost (i.e., wholesale price) is positively related to the production cost. As a consequence, the retailer has an incentive to lower the production costs when it sets the retail price.

If the manufacturer faces a capacity constraint or some diseconomies of scale, in general, the per-unit production cost increases with respect to the quantity. Then, the retailer, when facing a variable wholesale price positively related to the per-unit production cost, has an incentive to raise the retail price to reduce the sales. The reduced sales impair the manufacturer's profit because its per-unit revenue, based on a dollar-amount manufacturer margin or a percentage manufacturer margin, does not increase. Therefore, the manufacturer would rather choose a price-setting rule that sets a dollar-amount wholesale price. However, if through economies of scale the manufacturer's per-unit production cost declines with production, the retailer faces a variable wholesale price, which is negatively related to the sales, and thus has an incentive to cut the retail price to increase the sales. It will improve the manufacturer's profit if the per-unit revenue is fixed by a dollar-amount manufacturer margin. Therefore, the manufacturer should not choose a price-setting rule that sets a dollar-amount wholesale price.

If the manufacturer's per-unit production cost is decreasing, the manufacturer chooses a price-setting rule to set either a dollar-amount manufacturer margin or a percentage manufacturer margin. However, the manufacturer's decision depends on the elasticity of the cost function.

Proposition 2. *A Stackelberg leader manufacturer prefers a price-setting rule based on setting a percentage manufacturer margin as opposed to one based on setting a dollar-amount manufacturer margin if two conditions hold: (a) The manufacturer's marginal production cost is a monotonically decreasing function of the quantity, and (b) the elasticity of the cost function is less than 1.*

See Appendix A for the proof. The basic intuition is as follows: When we compare the rule based on percentage manufacturer margin with one based on dollar-amount manufacturer margin, on the one hand, the former tempts the retailer to further cut the retail price because the resultant wholesale price is more sensitive to the per-unit production cost under the percentage margin-based price-setting rule than that under the dollar-amount margin-based price-setting rule. As a result, the manufacturer sells more products to the retailer when it uses a rule based on setting a percentage manufacturer margin. On the other hand, the manufacturer's per-unit revenue decreases because it is proportional to the production cost, which is reduced by the economies of scale. Therefore, whether a price-setting rule that sets a percentage margin is more profitable for the manufacturer than the rule that sets a dollar-amount manufacturer margin depends on the elasticity of the cost function. In other words, it depends on whether increased production will bring more profit or decreased manufacturer margin (proportional to the production cost) will incur more loss.

The manufacturer's choice of price-setting rules affects not only its profit but also the retailer's profit and the total channel profit. Specifically,

Proposition 3. *When a Stackelberg leader manufacturer's production cost function is a monotonically decreasing function of the quantity, the total channel profit will increase when it switches from a price-setting rule based on setting a dollar-amount wholesale price to a price-setting rule based on setting a dollar-amount manufacturer margin.*

See Appendix A for the proof. When considering the production cost, the inefficiency of the supply chain lies not only in the double-marginalization problem but also in the potential ignorance of the production cost control. When the manufacturer

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chooses a price-setting rule based on setting a dollar-amount wholesale price, the retailer's cost is not related to the production cost. Thus, the retailer does not consider the effect of sales on the production cost when setting the retail price. Given a decreasing production cost function, the resultant retail price under a price-setting rule based on setting a dollar-amount wholesale price will be higher than the optimal level and consequently will damage the total channel profit. When the manufacturer chooses a price-setting rule based on setting a dollar-amount manufacturer margin, the retailer's cost is directly related to the per-unit production cost. The retailer will cut the retail price, thus increasing sales and lowering the production cost. The total channel profit increases as a result. In the next section, we describe the games with the retailer as the Stackelberg leader.

Case 2. *The retailer is modeled as a Stackelberg leader.*

If the retailer is modeled as a Stackelberg leader, its choice of price-setting rules and its decision regarding the corresponding pricing variables will affect the production cost and, consequently, the manufacturer's decision regarding the wholesale price. Again, we use backward induction to analyze the equilibrium.

The manufacturer's profit-maximizing problem is $\pi_m = (w - c) \cdot q$. The first-order condition varies according to the retailer's choice of the price-setting rules as follows:

a. If the retailer adopts a price-setting rule based on setting a dollar-amount retail price p, the manufacturer will always set the wholesale price equal to p because its first-order condition is always positive:

$$\frac{\partial \pi_m}{\partial w} = q > 0. \tag{4}$$

b. If the retailer adopts a price-setting rule based on setting a dollar-amount retail margin r, and $p = w + r$, the manufacturer solves the following:

$$\frac{\partial \pi_m}{\partial w} = (w - c) \cdot \frac{\partial q}{\partial p} + q\left(1 - \frac{\partial c}{\partial q}\frac{\partial q}{\partial p}\right) = 0. \tag{5}$$

c. If the retailer adopts the price-setting rule based on setting a percentage retail margin β, and $p = w(1 + \beta)$, the manufacturer solves the following:

$$\frac{\partial \pi_m}{\partial w} = (1 + \beta)(w - c)\frac{\partial q}{\partial p} + q\left(1 - (1 + \beta)\frac{\partial c}{\partial q}\frac{\partial q}{\partial p}\right) = 0. \tag{6}$$

Note that setting a dollar-amount retail price is never the retailer's optimal price-setting rule. Otherwise, the manufacturer as a Stackelberg follower will always raise the wholesale price to extract all the channel profit. Accordingly, we state the following proposition:

Proposition 4. *(a) A Stackelberg leader retailer prefers a price-setting rule based on setting a percentage retail margin as opposed to a rule based on setting a dollar-amount retail margin if the manufacturer's per-unit production cost is a monotonically decreasing function of the quantity or if the manufacturer's per-unit production cost is a monotonically increasing function of the quantity, but the elasticity of the cost function is less than the percentage manufacture margin; (b) otherwise, the retailer prefers a rule based on setting a dollar-amount retail margin as opposed to one based on setting a percentage retail margin.*

See Appendix A for the proof. When the retailer chooses a price-setting rule based on setting a percentage retail margin instead of a dollar-amount retail margin, the manufacturer faces a demand more elastic than the original demand and thus has a stronger incentive to cut the wholesale price to increase the resultant sale. The lower wholesale price benefits the retailer.

In addition, if the production cost is not constant, when setting the wholesale price, the manufacturer considers its effect not only on demand but also on production cost. If the production cost is decreasing, the manufacturer would want to cut the wholesale price because the resultant increase in sales would also lower the per-unit production cost. If the production cost is an increasing function of production quantity, when the manufacturer cuts the wholesale price, the increased sales benefits the manufacturer but, at the same time, reduces its margin as the per-unit production cost increases. Therefore, the manufacturer would want to cut the wholesale price if and only if the manufacturer margin (the marginal gain of the manufacturer's profit when sales increase) is higher than the elasticity of the production cost with respect to the production quantity (the marginal loss of the manufacturer's profit when sales increases).

Case 3. *The manufacturer is modeled as Bertrand–Nash competitor to the retailer.*

When the manufacturer and the retailer are modeled as Bertrand–Nash competitors to each other, their choices of price-setting rules and decisions about corresponding pricing variables affect the other party's decision.

When the manufacturer chooses among the price-setting rules, it anticipates the retailer's best response regarding the retail price to the three price-setting rules. Given the retailer's best response, as reflected by the retail price, the manufacturer optimizes its pricing variables to maximize the profit under the three price-setting rules. It then compares the three maximized profits to choose the optimal price-setting rule. Because the retailer's best response functions are the same when it is a Stackelberg follower and when it is a Bertrand–Nash competitor, Eqs. (1)–(3) also apply to Case 3. Because when the manufacturer compares the three price-setting rules, its decision is completely based on the retailer's best response functions (see the proof of Proposition 1 and Proposition 2), the manufacturer's choice of the price-setting rule is the same as its choice when it is a Stackelberg leader.

Proposition 5. *When the manufacturer is Bertrand–Nash competitor to the retailer,*

(a) *If the manufacturer's per-unit production cost is a monotonically increasing function of the quantity, its optimal*

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strategy is to choose the price-setting rule based on setting a dollar-amount wholesale price;

(b) *If the manufacturer's per-unit production cost is a monotonically decreasing function of the quantity and if the elasticity of the cost function is greater than 1, its optimal choice is the price-setting strategy based on setting a dollar-amount manufacturer margin;*

(c) *If the manufacturer's per-unit production cost is a monotonically decreasing function of the quantity and if the elasticity of the cost function is less than 1, its optimal choice is the price-setting strategy based on setting a percentage manufacturer margin.*

Similarly, regarding the retailer's choice of the price-setting rules, Eqs. (4)–(6) also apply to the Case 3. Therefore, the retailer's choice of the price-setting rules is the same as its choice when it is Stackelberg leader.

Proposition 6. *When the retailer is a Bertrand–Nash competitor to the manufacturer, its strategy is to choose a price-setting rule based on setting a percentage retail margin if (a) the manufacturer's per-unit production cost is a monotonically decreasing function of the quantity or if the manufacturer's per-unit production cost is a monotonically increasing function of the quantity, but the elasticity of the cost function is greater than 1. (b) Otherwise, the retailer's optimal strategy is to choose a price-setting rule based on setting a dollar-amount retail margin.*

Note that though the manufacturer's and the retailer's choices of the price-setting rules are the same as their choices when they are the Stackelberg leader, the optimal values of their chosen pricing variables are different from the case in which they are Stackelberg leaders. This is because in Bertrand–Nash competition, the equilibrium wholesale price and retail price are determined by both the manufacturer's and the retailer's best response functions. In the next section, we describe some results from the surveys that we conducted with manufacturers and retailers and some empirical results.

Empirical methodology

We employed a survey methodology for data collection. The unit of analysis was the manufacturer that dealt with a retailer. We decided to individually request a total of 150 manufacturers. During the phone calls, we introduced ourselves as professors in a business school and provided a brief summary of the research that we were conducting and asked them if they were interested in participating in a survey on the Internet. We assured them that they would have total anonymity if they participated in the survey. If they were interested, we requested their e-mail addresses and followed up with an e-mail that contained a link to the survey questionnaire on www.surveymonkey.com. This process yielded a total of 31 completed surveys from manufacturers. We discarded 3 surveys because of ambiguity in the answers and ultimately used 28 completed surveys (19%).

Our key interest is to determine whether the nature of the cost function affects the manufacturer's choice of price-setting rules.

Table 3
Descriptive statistics.

Variables	*N*	Mean	S.D.	Minimum	Maximum
Firm size (*SIZE*)	28	.5	.51	0	1
Cost structure (*COST*)	28	.64	.49	0	1
Competitors (*COMP*)	28	12.68	18.36	2	100
Firm age (*AGE*)	28	46.96	40	2	150

However, it is important to remember that most manufacturers produce many product lines and many stockkeeping units. Realizing that the manufacturer's pricing and other strategies could vary depending on the product line, in the questionnaire, we asked respondents to focus on one of their key product lines when answering the survey. To this end, we coded the dependent variable, *PRICING*, as a dummy variable that received a value of 1 if the manufacturer's pricing was based on margin considerations (either a dollar-amount margin or a percentage margin, but generally understood to be fixed in nature) and 0 if otherwise. The key independent variable for the study was the manufacturer's cost structure; we also coded the variable *COST* as a dummy, which took a value of 1 if the cost structure was nonincreasing and 0 if otherwise. Thus, if the manufacturer indicated that the cost would not change with an increase in production quantity, we coded *COST* as 1 (i.e., nonincreasing). We also asked the respondents to indicate their total sales as an indication of firm size, *SIZE*. Because there was wide variation in firm size, we coded a dummy variable 1 if the size exceeded $10 million and 0 if otherwise. Along with firm size, we coded the age of the firm, *AGE*. We also coded the number of competitors, *COMP*, for the key product line. Finally, we created one interaction, *COST* × *SIZE*. Table 3 reports the descriptive statistics, and Table 4 reports the correlations.

The choice of a categorical dependent variable means that we should run a logit or probit model. However, the small sample size prevented us from running such a model. Thus, we were confined to running a linear probability model. Linear probability models are widely used (see, e.g., Avery et al. 2007; Wooldridge 2003). To control for heteroskedasticity, we used White's standard errors. Table 5 reports the regression results. The coefficient of *COST* is positive and significant. Thus, the manufacturer's cost structure has a positive impact on its pricing strategy. A nonincreasing cost structure is more likely to be associated with a pricing strategy based on margin considerations. The main effect of *SIZE* is positive but not significant. However, the interaction coefficient of *SIZE* × *COST* is negative and significant, meaning that the relationship between *PRICING*

Table 4
Correlation table.

Variables	PRICING	SIZE	COST	COMP	AGE
Pricing structure (*PRICING*)	1.00				
Firm size (*SIZE*)	.07	1.00			
Cost structure (*COST*)	−.03	−.00	1.00		
Competitors (*COMP*)	.15	.29	−.25	1.00	
Firm age (*AGE*)	−.09	−.37	.59	−.16	1.00

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Table 5
Regression results.

Variables	Coefficient	S.E.
Constant	.46	.25
Firm size (*SIZE*)	.55	.37
Cost structure (*COST*)	.54**	.23
COST × *SIZE*	−.88**	.36
Firm age (*AGE*)	−.002	.003
Competitors (*COMP*)	.001	.002
R-square	.21	
F(5, 22)	3.19	
Prob > *F*	.02	
RMSE	.47	
N	28	

Notes: The dependent variable is *PRICING*. RMSE = root mean square error. White's heteroskedasticity-adjusted errors are used.
** Significant at .05 level.

and *COST* depends of the level of *SIZE*. Smaller companies are more willing to adopt margin-based pricing when *COST* is nonincreasing. The effect of *COMP* is positive but not significant. Thus, overall, although the empirical results are narrow in scope, they nevertheless suggest a statistically significant relationship between the manufacturer's cost structures and its pricing strategy when dealing with retailers. The variance inflation factors (VIFs) indicate that multicollinearity is not a problem. None of the VIFs were larger than 4.35, with the mean VIF being 2.89.

Discussion and conclusion

This article extends prior marketing literature on channels in two critical ways. First, few analytical marketing models of manufacturer–retailer relationships account for nonlinearity in the production cost function and its impact on the equilibrium outcomes and the channel relationship. We address this issue here specifically, assuming a generalized production cost function. Second, both in theory and in practice, we observe manufacturers and retailers choosing different price-setting rules. Our survey supports this general observation. A natural theoretical question, then, is whether in a manufacturer–retailer relationship the equilibrium outcomes are invariant with respect to the manufacturer's (retailer's) choice of the price-setting rules.

In this article, we assume a generalized per-unit cost function and model manufacturer–retailer relationships in several well-analyzed game forms used in the marketing literature: (1) the manufacturer as a Stackelberg leader to the retailer, (2) the retailer as a Stackelberg leader to the manufacturer, and (3) the manufacturer and the retailer as Bertrand–Nash competitors. We find several noteworthy results.

First, when the manufacturer is a Stackelberg follower, it is indifferent to the choice of the price-setting rule. However, when it is a Stackelberg leader or a Bertrand–Nash competitor to the retailer, the manufacturer's choice of a price-setting rule depends on the nature of the production cost function. If the per-unit production cost function is increasing because of diseconomies of scale, the manufacturer strictly prefers the price-setting rule based on setting a dollar-amount wholesale price as opposed to the rule based on setting a manufacturer margin. If the per-unit production cost function is decreasing because of economies of scale, the manufacturer prefers the price-setting rule based on setting a dollar-amount manufacturer margin as opposed to the rule based on setting a dollar-amount wholesale price. Furthermore, if the per-unit cost function is decreasing and the elasticity of the per-unit cost function is less than unity, the manufacturer prefers the price-setting rule based on setting a percentage manufacturer margin.

Second, when the retailer is a Stackelberg follower, it is indifferent to the choice of price-setting rules. However, if the retailer is a Stackelberg leader or a Bertrand–Nash competitor to the manufacturer, the retailer prefers the price-setting rule based on setting a percentage retail margin if the manufacturer's per-unit cost is a decreasing function of production quantity or if the manufacturer's per-unit cost is an increasing function of production quantity but the elasticity of the cost function is less than the manufacturer margin; otherwise, the retailer would rather choose the price-setting rule based on setting a dollar-amount retail margin.

Third, if the manufacturer is a Stackelberg leader and the manufacturer's per-unit production cost is a decreasing function of production quantity, when the manufacturer switches its price-setting rule based on setting a dollar-amount wholesale price to the one based on setting a dollar-amount manufacturer margin, the total channel profit increase.

The empirical results show that manufacturer's cost structure has a positive impact on price-setting rules. In other words, a nonincreasing cost structure is more likely to be associated with price-setting rules based on margin considerations. Notably, the interaction of cost and firm size has a negative and significant coefficient, indicating that for any given cost structure, smaller firms are perhaps more likely to adopt price-setting rules based on setting margins. Although the empirical results are narrow in scope, they nevertheless suggest a relationship between the manufacturer's cost structures and its choice of the price-setting rule—a subject that has not received much consideration in the marketing literature.

Productions costs play a significant role in every industry. How such production costs affect channel relationship is an underexplored area. We attempt to capture some complexities involved in a manufacturer–retailer relationship by specifically incorporating the costs of production both theoretically and empirically. Much more remains to be done in this area.

Appendix A.

A.1. Proof of Proposition 1

In the following proofs, we make an additional assumption that regardless of the manufacturers' choice of the price-setting rules – that is, setting a dollar-amount wholesale price, setting a dollar-amount manufacturer margin, or setting a percentage manufacturer margin – the retailer has a unique set of local optimal retail prices, or $\partial^2\pi_r/\partial p^2 \leq 0$.

When the manufacturer charges a dollar-amount wholesale price w, set $p^w|_w$, $q^w|_w$, and $c^w|_w$ as the retailer's optimal retail price, sale quantity, and the manufacturer's resultant per-unit

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production cost given w. Here, $p^w|_w$ is defined by Eq. (1). Set $\pi_m^w|_w = (w - c^w|_w) \cdot q^w|_w$ as the manufacturer's profit function. Set w^* as the manufacturer's optimal wholesale price.

When the manufacturer charges a dollar-amount manufacturer margin m, set $p^m|_m$, $q^m|_m$, and $c^m|_m$ as the retailer's optimal retail price, sale quantity, and the manufacturer's resultant per-unit production cost given m. Here, $p^m|_m$ is defined by Eq. (2). Set $\pi_m^m|_m = m \cdot q^m|_m$ as the manufacturer's profit function. Set m^* as the manufacturer's optimal dollar-amount margin.

When the manufacturer charges a percentage manufacturer margin α, set $p^\alpha|_\alpha$, $q^\alpha|_\alpha$, and $c^\alpha|_\alpha$ as the retailer's optimal retail price, sale quantity, and the manufacturer's resultant per-unit production cost given α. Here, $p^\alpha|_\alpha$ is defined by Eq. (3). Set $\pi_m^\alpha|_\alpha = \alpha \cdot c^\alpha|_\alpha \cdot q^\alpha|_\alpha$ as the manufacturer's profit function. Set α^* as the manufacturer's optimal percentage margin.

We first prove that manufacturer prefers the rule based on setting a dollar-amount margin as opposed to the rule based on setting a dollar-amount wholesale price when $\partial c/\partial q < 0$. Consider a case in which the manufacturer does not charge the optimal dollar-amount manufacturer margin m^* but rather charges a dollar-amount manufacturer margin $m' = w^* - c^w|$; then, the retailer's optimal retail price is denoted as $p^m|$, where

$$\frac{\partial \pi_r}{\partial p}| = q^m| \left(1 - \frac{\partial c}{\partial q}| \cdot \frac{\partial q}{\partial p}|\right) + \left(p^m| - c^m| - m'\right) \frac{\partial q}{\partial p}| = 0$$

Recall that when the manufacturer charges the optimal dollar-amount wholesale price w^*, the retailer's optimal retail price $p^w|$ satisfies Eq. (1), or $q^w| + (p^w| - w^*)(\partial q/\partial p)| = 0$. Because $\partial c/\partial q < 0$ and $\partial q/\partial p < 0$, $q(\partial c/\partial q)(\partial q/\partial p) > 0$. Thus, if the retailer still sets the retail price as $p^w|$ when facing m', $\partial \pi_r/\partial p| = q^w|(1 - (\partial c/\partial q)| \cdot (\partial q/\partial p)|) + (p^w| - w^*)(\partial q/\partial p)| < 0$, $(\partial \pi_r/\partial p)| < 0$, and $\partial \pi_r/\partial p| = 0$; therefore, $p^m| < p^w|$ Consequently, $q^m| > q^w|$. Therefore, the manufacturer's profit is higher by setting m' than by setting w^*, or $\pi^m| = m' \cdot q^m| > (w^* - c^w|)q^w| = \pi^w|$.

Because m^* is the optimal dollar-amount manufacturer margin, $\pi^m| \geq \pi^m| > \pi^w|$. Thus, the manufacturer prefers the dollar-amount margin to the dollar-amount wholesale price when $\partial c/\partial q < 0$.

It is worth noting that the optimal percentage manufacturer margin does not necessarily benefit the manufacturer more than the optimal dollar-amount wholesale price. When the manufacturer charges the percentage margin, the retailer has more incentive to reduce the retail price. The lower retail price increases sales but also lowers the per-unit production cost, which consequently reduces the manufacturer's per-unit profit.

We then prove that when $\partial c/\partial q > 0$, the manufacturer prefers the rule based on setting a dollar-amount wholesale price as opposed to the rule based on setting a dollar-amount manufacturer margin or a percentage manufacturer margin. Consider a case in which the manufacturer charges a dollar-amount manufacturer margin $w' = m^* + c^m|$; then, the retailer's optimal retail price is denoted as $p^w|$, where $(\partial \pi_r/\partial p)| = q^w| + \left(p^w| - w'\right)(\partial q/\partial p)| = 0$.

Recall that when the manufacturer charges the optimal dollar-amount manufacturer margin m^*, the retailer's optimal retail price $p^m|$ satisfies Eq. (2), or $q^m|(1 - (\partial c/\partial q)| \cdot (\partial q/\partial p)|) + m^* \cdot (\partial q/\partial p)| = 0$.

Because $\partial c/\partial q > 0$ and $\partial q/\partial p < 0$, $q(\partial c/\partial q)(\partial q/\partial p) < 0$. Thus, if the retailer still sets the retail price as $p^m|$ when facing w', $(\partial \pi_r/\partial p)| = q^m| + \left(p^m| - w'\right) \cdot (\partial q/\partial p)| = q^m| + m^* \cdot (\partial q/\partial p)| < 0$, $(\partial \pi_r/\partial p)| < 0$, and $(\partial \pi_r/\partial p)| = 0$; therefore, $p^w| < p^m|$.

Consequently, $q^w| > q^m|$ and $c^w| < c^m|$.

Therefore, the manufacturer's profit is higher by setting w' than by setting m^*, or $\pi_m^w| = \left(w' - c^w|\right) q^w| > m^* \cdot q^m| = \pi_m^m|$

Because w^* is the optimal dollar-amount wholesale price, $\pi^w| \geq \pi^w| > \pi^m|$. Thus, the manufacturer prefers the rule based on the optimal dollar-amount wholesale price as opposed to the rule based on the optimal dollar-amount margin.

Similarly, set $w' = (1 + \alpha^*) \cdot c^\alpha|$; we can show that $\pi^w| \geq \pi^w| > \pi^\alpha|$. The manufacturer prefers the rule based on the optimal dollar-amount wholesale price as opposed to the rule based on the optimal percentage margin.

A.2. Proof of Proposition 2

In this case, we show that if $-(\partial c/\partial q) \cdot (q/c) < 1$, manufacturers prefer the rule based on the optimal percentage margin as opposed to the rule based on the optimal dollar-amount margin. If we consider the case in which the manufacturer charges a percentage margin $\alpha' = m^*/c^m| - 1$, the retailer's optimal retail price is denoted as $p^\alpha|$, where $(\partial \pi_r/\partial p)| = q^\alpha| \left(1 - (1 + \alpha')(\partial c/\partial q)| \cdot (\partial q/\partial p)|\right) + \left(p^\alpha| - (1 + \alpha')c^\alpha|\right)(\partial q/\partial p)| = 0$

Recall that when the manufacturer charges the optimal dollar-amount manufacturer margin m^*, the retailer's optimal retail price $p^m|$ satisfies Eq. (A.2), or $q^m|(1 - (\partial c/\partial q)| \cdot (\partial q/\partial p)|) + m^* \cdot (\partial q/\partial p)| = 0$.

Because $\partial c/\partial q < 0$ and $\partial q/\partial p < 0$, $q(\partial c/\partial q)(\partial q/\partial p) > 0$. Thus, if the retailer still sets the retail price as $p^m|$ when facing α', $(\partial \pi_r/\partial p)| = q^m| \left(1 - (1 + \alpha')(\partial c/\partial q)| \cdot (\partial q/\partial p)|\right) + \left(p^m| - (1 + \alpha')c^m|\right)(\partial q/\partial p)| < 0$.

Because $\frac{\partial \pi_r}{\partial p}| = 0$, therefore, $p^\alpha| < p^m|$.

Consider the function $g \equiv c \cdot q$; then, $\partial g/\partial p = (\partial g/\partial p)((\partial c/\partial q)q + c)$. If $-\frac{\partial c}{\partial q} \cdot \frac{q}{c} < 1$, then $\frac{\partial g}{\partial p} < 0$. Therefore, $c^\alpha| \cdot q^\alpha| > c^m| \cdot q^m|$. Then, the manufacturer's profit is higher by charging α' than by charging m^*, or $\pi_m^\alpha| = \alpha' \cdot c^\alpha| \cdot q^\alpha| > \alpha' \cdot c^m| \cdot q^m| = \pi_m^m|$

Because α^* is the optimal percentage margin, $\pi_m^\alpha| \geq \pi_m^\alpha| > \pi_m^m|$. Thus, the manufacturer prefers to charge a percentage margin as opposed to charging a dollar-amount price.

A.3. Proof of Proposition 3

Denote π_T as the total channel profit, $\pi_T = (p - c) \cdot q$. Consider the case in which the manufacturer and the

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retailer compromise to maximize the total channel profit. Denote p^* as the optimal retail price. Then, $(\partial\pi/\partial p)\mid = q\,(1-(\partial c/\partial q)\cdot(\partial q/\partial p))+(p-c)\cdot(\partial q/\partial p)=0$.

Consider the case in which the manufacturer charges an optimal dollar-amount wholesale price w^* and the retailer chooses the optimal retail price p_{w^*}. Given Eq. (A.1),

$$\frac{\partial\pi_T}{\partial p}\mid = \frac{\partial\pi_r}{\partial p}+(w-c)\frac{\partial q}{\partial p}-q\cdot\frac{\partial c}{\partial q}\cdot\frac{\partial q}{\partial p}$$
$$=(w-c)\frac{\partial q}{\partial p}-q\cdot\frac{\partial c}{\partial q}\cdot\frac{\partial q}{\partial p} \quad (A.1)$$

Consider the case in which the manufacturer charges an optimal dollar-amount manufacturer margin m^* and the retailer chooses the optimal retail price p_{m^*}. Given Eq. (A.2),

$$\frac{\partial\pi_T}{\partial p}\mid = \frac{\partial\pi_r}{\partial p}+(w-c)\frac{\partial q}{\partial p}=(w-c)\frac{\partial q}{\partial p} \quad (A.2)$$

Therefore, when $\frac{\partial c}{\partial q}<0$, $\frac{\partial\pi_T}{\partial p}\mid < \frac{\partial\pi_T}{\partial p}\mid < \frac{\partial\pi_T}{\partial p}\mid$. Because $\frac{\partial^2\pi}{\partial p^2}<0$, we have $p_{w^*}>p_{m^*}>p^*$ and $\pi_T\mid > \pi_T\mid > \pi_T\mid$.

A.4. Proof of Proposition 4

Define $\gamma=\partial p/\partial w$; then, $\gamma=1+\beta$ when the retailer charges a percentage retail margin, and $\gamma=1$ when the retailer charges a dollar-amount retail margin. The retailer's profit is $\pi_r=(p-w)q$. Using the envelope theorem, we get $\partial\pi_r/\partial\gamma=-(\partial w/\partial\gamma)q$.

Thus, the comparative static on the retailer's profit depends on how the manufacturer's optimal wholesale prices, w, changes with parameter γ. If $\partial w/\partial\gamma<0$, the retailer prefers the rule based on setting a percentage retail margin to the rule based on setting a dollar-amount retail margin; otherwise, the retailer prefers the rule based on setting a dollar-amount retail margin.

The manufacturer's profit function is $\pi_m=(w-c)\,q$. Thus, the first-order condition is

$$H\equiv\frac{\partial\pi_m}{\partial w}=(w-c)\,\frac{\partial q}{\partial p}\gamma+q\left(1-\frac{\partial c}{\partial q}\frac{\partial q}{\partial p}\gamma\right)=0.\ \text{Thus,}\ \frac{\partial w}{\partial\gamma}$$
$$=-\frac{\partial H/\partial\gamma}{\partial H/\partial w}=-\frac{c\cdot\partial q/\partial p\left((w/c)-1-\frac{\partial c/c}{\partial q/q}\right)}{\partial^2\pi_m/\partial w^2}.$$

Because $\partial^2\pi_m/\partial w^2\le 0$ and $\partial q/\partial p<0$, if $\partial c/\partial q<0$ or $\partial c/\partial q>0$ but $(\partial c/c)/(\partial q/q)<(w/c)-1$, then $\partial w/\partial\gamma<0$, and the retailer prefers the rule based on setting a percentage retail margin as opposed to the rule based on setting a dollar-amount retail margin. Otherwise, if $(\partial c/c)/(\partial q/q)>(w/c)-1$, $\partial w/\partial\gamma>0$, the retailer prefers the rule based on setting a dollar-amount retail margin as opposed to the rule based on setting a percentage retail margin.

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