Does Advertising Make Price Promotions More Effective?

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Abstract

This study attempts to reconcile two controversial schools of thought concerning the effect of advertising on price sensitivity. A rational expectations model shows that an advertising threshold of quality indication exists. Before reaching the threshold, consumers depend more on prices to infer product quality as advertising information diffuses. At this stage, advertising decreases price sensitivity and makes price promotions an ineffective way to induce sales. After advertising coverage crosses this threshold, consumers gradually tend to use advertising information to infer product quality. At this stage, advertising increases price sensitivity and complements price promotions. The nonlinear relationship between advertising and price sensitivity offers practical implications. When a product is in its introductory stage, the price should be stable as the manufacturer increases advertising expenditures. Over time, the demand for price stabilization declines as advertising coverage gradually increases. This study also provides suggestions for antitrust policy.

Keywords: Advertising Information, Price-Quality Relationship, Price Sensitivity.

I. Introduction

Models of advertising and their effects on price are based on two broad economic theories. One predicts that advertising reduces the elasticity of price because firms use advertising to create brand loyalty that makes consumers less sensitive to prices (Bain, 1956; Comanor and Wilson, 1974; Lambin, 1976; Popkowski-Leszczyc and Rao, 1989; Boulding et al., 1994). In contrast, the other theory regards advertising as a source of information about choices. From this viewpoint, advertising increases price elasticity by allowing consumers to comparison shop (Stigler, 1961; Nelson, 1974; Steiner, 1993; Shankar and Bolton, 2004; Chen, 2010). Unless a reconciliatory theory is provided, it is difficult for such conflicting results to offer practical guidelines.

Price can serve as a signal of quality; the quality-assuring price must be large enough to make the value of repeated sales exceed the one-time gain from cheating, so the firms will never find it optimal to cheat consumers. Any individual who observes a firm attempting to sell a product for less than the quality-assuring price would infer the product is a low-quality product (Klein and Leftler, 1981; Bagwell and Riordan, 1991; Kirmani and Rao, 2000). Evidence for a robust price-quality effect has been extensively recognized in empirical studies (McConnell, 1968; Monroe, 1973; Rao and Monroe, 1989; Dodds et al., 1991). Considering the price-quality relationship, price promotions simultaneously have two opposing effects on sales. One increases the sales quantity due to the downward sloping demand curve, which is referred to as the positive effect brought about by price promotions. The other depresses the sales quantity, due to consumers' misinterpretation of the price cuts as reductions in quality, which is referred to as the negative effect brought about by price promotions.

A product with less negative effects caused by price promotions has a greater chance of being selected by retailers as a "loss leader". Retailers use it to build store traffic on the assumption that consumers will purchase other products in addition to the promoted products. In this study, we show that an advertising threshold can determine if advertising reduces negative effects from price promotions. Before reaching the threshold, consumers depend more on prices to infer product quality as advertising information diffuses. At this stage, advertising decreases price sensitivity and price

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promotions cannot bring desired results. After advertising coverage crosses this threshold, consumers gradually tend to use advertising information to infer product quality. At this stage, advertising increases price sensitivity and makes price promotions an effective way to induce sales. The logic of U-shape relationship between advertising and price sensitivity can help retailers design efficient promotion strategies.

The logics of this study are demonstrated by a rational expectations model. This model was initially proposed by Lucas (1972), who developed the concept of equilibrium, where individuals utilize statistical relationships between endogenous and exogenous variables. Grossman (1976) analyzed an economy in which traders hold diverse information in regard to the return on assets and claimed investors can infer the asset's return through the price alone because all information is contained therein. Grossman and Stiglitz (1980) proposed that the market must contain a source of noise preventing agents from obtaining all the information from the price, creating an incentive to expend resources upon obtaining information. Hellwig (1980) argued that since noise comes from the supply side, the price cannot provide sufficient information, and so, simply observing price cannot provide enough information to predict the asset's return. Admati (1985) provided generalized solutions for the rational expectations equilibrium models developed by Hellwig (1980). Finally, noisy rational expectations equilibrium has been applied to various issues in financial economics (Diamond, 1985; Diamond and Verrecchia, 1991; Easley and O'Hara, 2004; Ozdenoren and Yuan, 2008).

II. Model

Consider a product held by a risk-neutral retailer that faces a finite number of consumers. The retailer has monopolistic power that enables it to reduce retail prices by increasing retail supply. The assumption that a retailer can have market power is not unrealistic (Dobson, 2005). Let $\lambda \in (0,1)$ be the fraction of consumers whose expectations regarding quality are based both on manufacturer advertising and retail price, and $1-\lambda$ be the fraction of consumers inferring quality only by observing the retail price.

Suppose that the value of quality conveyed by manufacturer advertising is

$$a = q + \varepsilon \tag{1}$$

where a denotes the advertising information received by consumers. It expresses true quality q but is perturbed by noise ε. Assume ε is normally distributed with a mean of zero and a variance of σ_a, and q is normally distributed with a mean of $\bar{q} > 0$ and a variance of σ_q. The demand function of consumers that infer quality only by observing the retail price is

$$z_d(p) = \gamma Var(q|p)^{-1}\left(E(q|p) - p\right) \tag{2}$$

And the demand function of consumers that infer quality by advertising and retail price is

$$z_d(a,p) = \gamma Var(q|a,p)^{-1}\left(E(q|a,p) - p\right) \tag{3}$$

where z_d denotes demand quantities, $\gamma > 0$ is the level of risk tolerance, and p denotes the retail price. Suppose that (q,a,p) has a joint normal distribution, the mean and variance of consumers who can observe advertising take the following forms

$$E(q|a,p) = h_0 + h_1 a + h_2 p \tag{4}$$

$$Var(q|a,p) = v_0 \tag{5}$$

The mean and variance of consumers who can only observe retail price are

$$E(q|p) = c_0 + c_1 p \tag{6}$$

$$Var(q|p) = d_0 \tag{7}$$

The retailer launches price promotions by altering supply quantity, the retail supply is denoted by z_s, which has normal distribution with a mean of $\bar{z} > 0$ and a variance of σ_s. The retail supply variance σ_s represents the intensity of price promotions, meaning that the retailer can accumulate a certain amount of goods and then release them on one occasion while providing discounts.

III. Advertising and Price Promotions

We let $\bar{z}_d$ denote the average demand quantity, which is the weighted average of informed consumers and uninformed consumers' quantity:

$$\bar{z}_d = \lambda z_d(a, p) + (1-\lambda) z_d(p) \tag{8}$$

Substituting Equation 2 and 3 into Equation 8, we have

$$\bar{z}_d = \lambda\gamma \frac{[E(q|a,p) - p]}{Var(q|a,p)} + (1-\lambda)\gamma \frac{[E(q|p) - p]}{Var(q|p)} \tag{9}$$

Then we substitute Equation 4 ~ 7 into Equation 9, we have

$$\bar{z}_d = \lambda\gamma\left[\frac{h_0 + h_1 a + h_2 p - p}{v_0}\right] + (1-\lambda)\gamma\left[\frac{c_0 + c_1 p - p}{d_0}\right] \tag{10}$$

Let $\bar{z}_d = z_s$, we can obtain the equilibrium price. Quality-related information can be conveyed by the retail price, but it is perturbed by noise from the retail supply. The amount of quality information a consumer acquires is determined, in part, through the retail price. The retail price, in turn, depends on the amount of quality information that consumers acquire. The equilibrium retail price and information acquisition have to be solved simultaneously, as each one affects the other.

Lemma 1. A rational expectations price p, for a given value of λ, is a linear function of advertising information a and retail supply z_s.

$$p = b_0 + b_1 a - b_2 z_s \tag{11}$$

where

$$b_0 = \frac{v_0 d_0}{(\lambda d_0 + (1-\lambda)v_0)}\left[\frac{1}{\sigma_q}\bar{q} + \frac{\gamma\lambda}{(\gamma^2\lambda^2 + \sigma_s\sigma_a)}\bar{z}\right]$$

$$b_1 = \frac{v_0 d_0}{(\lambda d_0 + (1-\lambda)v_0)}\frac{\lambda}{\sigma_a}\left[1 + \frac{\gamma^2\lambda}{\gamma^2\lambda^2 + \sigma_s\sigma_a}\right]$$

$$b_2 = \frac{v_0 d_0}{(\lambda d_0 + (1-\lambda)v_0)}\frac{1}{\gamma}\left[1 + \frac{\gamma^2\lambda}{\gamma^2\lambda^2 + \sigma_s\sigma_a}\right]$$

$$v_0 = \left[\sigma_q^{-1} + \sigma_a^{-1} + (\sigma_a + \sigma_s\sigma_a^2(\gamma\lambda)^{-2})^{-1}\right]^{-1}$$

$$d_0 = \left[\sigma_q^{-1} + (\sigma_a + \sigma_s\sigma_a^2(\gamma\lambda)^{-2})^{-1}\right]^{-1}$$

Proof: Substituting Equations 4~7 into Equation 10, we have

$$b_0 = \frac{\lambda h_0 d_0 + (1-\lambda)c_0 v_0}{\lambda(1-h_2)d_0 + (1-\lambda)(1-c_1)v_0} \tag{12a}$$

$$b_1 = \frac{\lambda h_1 d_0}{\lambda(1-h_2)d_0 + (1-\lambda)(1-c_1)v_0} \tag{12b}$$

$$b_2 = \frac{d_0 v_0}{(\lambda(1-h_2)d_0 + (1-\lambda)(1-c_1)v_0)\gamma} \tag{12c}$$

The vector (q, a, p) is normally distributed with the variance-covariance matrix Σ:

$$\Sigma = \begin{bmatrix} \sigma_q & \sigma_q & \sigma_q b_1 \\ \sigma_q & \sigma_q + \sigma_a & \sigma_q b_1 \\ \sigma_q b_1 & \sigma_q b_1 & b_1^2(\sigma_q + \sigma_a) + b_2^2 \sigma_s \end{bmatrix}$$
. Following the techniques in Admati (1985) and Kuo (1992), we have Lemma 1. Then we show that an increase in the intensity of price promotions causes negative effects on expected price. Moreover, advertising can reduces these negative effects after advertising coverage crosses a threshold.

Proposition 1. An increase in the intensity of price promotions σ_s brings negative effects on expected price due to an increase in conditional risk over quality. However, threshold $\lambda^* = \sqrt{\sigma_s \sigma_a} / \gamma$ exists such that as $\lambda > \lambda^*$, an increase in advertising coverage λ can reduce the negative effects from σ_s.

Proof: First we need to show that $\partial E(p) / \partial \sigma_s < 0$. The expected price can be obtained from Equation 9:

$$E(p) = \bar{q} - \frac{d_0 v_0}{(\lambda d_0 + (1-\lambda) v_0)\gamma} \bar{z} \qquad (13)$$

Equation 11 can be rewritten as follows:

$$E(p) = \bar{q} - \left[\lambda v_0^{-1} + (1-\lambda) d_0^{-1}\right]^{-1} \gamma^{-1} \bar{z} \qquad (13a)$$

Differentiating v_0^{-1} and d_0^{-1} with respect to σ_s gives

$$\frac{\partial v_0^{-1}}{\partial \sigma_s} = \frac{\partial d_0^{-1}}{\partial \sigma_s} = -\left[\sigma_a + \sigma_s \sigma_a^2 (\gamma\lambda)^{-2}\right]^{-2} \sigma_a^2 (\gamma\lambda)^{-2} < 0 \qquad (14)$$

The first argument of Ptoposition2 is proved

$$\frac{\partial E(p)}{\partial \sigma_s} = \left[\lambda v_0^{-1} + (1-\lambda) d_0^{-1}\right]^{-2} \left[\lambda \frac{\partial v_0^{-1}}{\partial \sigma_s} + (1-\lambda) \frac{\partial d_0^{-1}}{\partial \sigma_s}\right] \gamma^{-1} \bar{z} < 0 \qquad (15)$$

Then, we denote the absolute value of $\left|\partial E(p) / \partial \sigma_s\right|$ as the negative effects caused by price promotions. To accomplish the proof, we need to show that $\frac{\partial\left(\left|\partial E(p) / \partial \sigma_s\right|\right)}{\partial \lambda} < 0$ as $\lambda > \lambda^*$, please see Appendix A.

Proposition1 indicates that, as $\lambda > \lambda^*$, negative effects from price promotions can be reduced by advertising. As more consumers observe advertising, the uncertainty faced by consumers declines. In such cases, practitioners would find advertising increases price sensitivity and makes price promotions effective. However, Proposition1 cannot hold as $\lambda < \lambda^*$. Proposition1 can explain the result in Proposition2.

Differentiating Equation 10 with respect to advertising coverage gives:

$$\frac{d\bar{z}_d}{dp} = \frac{\lambda\gamma(h_2 - 1) d_0 + (1-\lambda)\gamma(c_1 - 1) v_0}{v_0 d_0}$$

Let $\left|d\bar{z}_d / dp\right|$ denote the effective of price promotions, if one parameter leads to greater $\left|d\bar{z}_d / dp\right|$, it represents that this parameter make price promotions bring more sales.

Proposition 2. Threshold $\lambda^* = \sqrt{\sigma_s \sigma_a} / \gamma$ exists such that as $\lambda > \lambda^*$, an increase in advertising coverage λ makes price promotions bring more sales.

Proof: Please see Appendix B.

Proposition 2 ensures that advertising make price promotions an effective way to induce sales as $\lambda > \lambda^*$. The explanation for this result is provided in Proposition 1, which indicates that, after λ crosses λ^*, an increase in λ reduces the negative effects form price promotions and keeps positive effects. The risk reduction role of advertising lets consumers' demand more elastic, so price promotions could bring desired effects. This relationship is supported by theoretical and empirical studies (Stigler, 1961; Nelson, 1974; Albion, 1983; Steiner, 1993; Eskin and Baron, 1977; Wittink, 1977; Moriarty, 1983; Sethuraman and Tellis, 2002; Shankar and Bolton, 2004). However, Proposition2 might not hold as $\lambda < \lambda^*$. An increase in the proportion of informed consumers has two effects on the means of inferring quality: one is direct and the other is indirect. The direct effect is straightforward, since the proportion of informed consumers increases, average consumer depends more on advertising information to judge quality. Contrarily, the indirect effect makes average consumer depend less on advertising information to infer quality. Because more advertising information makes prices aggregate and reveal more information. Therefore, more informative price encourages consumers to depend more on price to infer quality. An increase in advertising strengthens both effects, and the effect that is dominant can determine whether advertising increases or decreases price elasticity. When advertising coverage exceeds the threshold λ^*, the first effect dominates the second effect. Consumers do not degrade their perception of the quality of these products even though price discounts are frequently offered. Under such circumstances, advertising increases price sensitivity and make price promotions more effective. However, as advertising coverage has not crossed the threshold λ^*, it is uncertain which of the two effects dominates. If second effect dominates, an increase in advertising persuades consumers to use price as an indicator of quality, the following circumstance might happen. Consumers who want to buy the advertised product go to a retail store. They see price promotions and wonder why the price would decline if the product quality were as good as it were claimed to be by advertising. They cannot determine whether the price promotion reflects low quality, or are merely the result of increased retail supply. Under this circumstance, the negative effects of price promotion can be augmented by advertising, which could decrease price sensitive and make price promotions an ineffective way to induce sales. The relationship is also supported by many researches (Bain, 1956; Comanor and Wilson, 1974; Lambin, 1976; Popkowski-Leszczyc and Rao, 1989; Boulding et al., 1994). The nonlinear relationship between information diffusion on price sensitivity is also discussed in other studies (Vanhonacker, 1989; Simon, 1989; Parker, 1992; Parker and Neelamegham, 1997), which show price elasticity first declines and then ultimately increases over the life cycle of products.

IV. Conclusions

The U-shape relationship between advertising and price sensitivity has two implications. The first is that a firm should keep the price stable when products are still in the introductory stage. Otherwise, consumers can be confused by price promotions. As the number of informed consumers increases and crosses the threshold, the firm can target advertised goods with price promotions. The second implication is that antitrust policies should reconsider the legal status of price-stabilization practices like resale price maintenance.[1] It is illegal in most countries, except under rule of reason in the United States. From the perspective of rational expectations model, resale price maintenance on products which are at introductory stage could be exempted from prohibition. Because the number of informed consumers is low in the introductory stage, the prohibition of resale price maintenance could reduce the strength of manufacturer advertising.

From these results, paradoxes arise between retailers and manufacturers. In the first paradox, if advertising coverage has exceeded the threshold, does the manufacturer get the full benefit from investing in advertising expenditures? The benefit of advertising seems to be shared with retailers because the advertised product becomes the retailer’s tool to draw store traffic. As noted above, the advertised good that serves to draw traffic can improve storewide sales by attracting more consumers. Even with a lower margin, a retailer still has incentives to carry a brand. Advertising increases the numbers of retailers that carry a product,. Moreover the manufacturer cannot benefit from advertising without the role of the retailer. As for the second paradox, if the advertising coverage has not exceeded the threshold,

[1] Please see Chen and Chen (2007, 2010) for a discussion of resale price maintenance.

why would a retailer carry a product if could not be used as a tool to draw store traffic? The reason is that retailers expect that consumers not only purchase the promoted goods ($\lambda > \lambda^*$), but also purchase goods that are at an introductory stage ($\lambda < \lambda^*$). Accordingly, practitioners can design efficient promotion programs that correspond with advertising.

Appendix A

The effect of advertising on the negative effects is

$$\frac{\left(\left|\frac{\partial E(p)}{\partial \sigma_s}\right|\right)}{\partial \lambda} = \frac{-\left[\frac{\partial v_0^{-1}}{\partial \sigma_s} + \lambda \cdot \frac{\partial v_0^{-1}/\partial \sigma_s}{\partial \lambda} + \frac{\partial d_0^{-1}/\partial \sigma_s}{\partial \lambda} - \frac{\partial d_0^{-1}}{\partial \sigma_s} - \lambda \cdot \frac{\partial d_0^{-1}/\partial \sigma_s}{\partial \lambda}\right]\left[\lambda \cdot v_0^{-1} + (1-\lambda) \cdot d_0^{-1}\right]^2}{\left[\lambda \cdot v_0^{-1} + (1-\lambda) \cdot d_0^{-1}\right]^4 \cdot \gamma \cdot \bar{z}^{-1}}$$
$$+ \frac{2 \cdot \left[\lambda \cdot \frac{\partial v_0^{-1}}{\partial \sigma_s} + (1-\lambda) \cdot \frac{\partial d_0^{-1}}{\partial \sigma_s}\right]\left[\lambda \cdot v_0^{-1} + (1-\lambda) \cdot d_0^{-1}\right]\left[v_0^{-1} + \lambda \frac{\partial v_0^{-1}}{\partial \lambda} + \frac{\partial d_0^{-1}}{\partial \lambda} - d_0^{-1} - \lambda \frac{\partial d_0^{-1}}{\partial \lambda}\right]}{\left[\lambda \cdot v_0^{-1} + (1-\lambda) \cdot d_0^{-1}\right]^4 \cdot \gamma \cdot \bar{z}^{-1}} \quad \text{(B1)}$$

If the value in Equation B1 is negative, then advertising can reduce the negative effects. First we examine the second term in the right-hand side of Equation B1. From Equation 12, we know that $\left[\lambda \frac{\partial v_0^{-1}}{\partial \sigma_s} + (1-\lambda) \frac{\partial d_0^{-1}}{\partial \sigma_s}\right] < 0$. Then we differentiate v_0^{-1} and d_0^{-1} with respect to λ, which yields the following expression

$$\frac{\partial v_0^{-1}}{\partial \lambda} = \frac{\partial d_0^{-1}}{\partial \lambda} = 2\left[\sigma_a + \sigma_s \sigma_a^2 (\gamma\lambda)^{-2}\right]^{-2} \sigma_s \sigma_a^2 \gamma^{-2} \lambda^{-3} > 0$$

Thus we can conclude the second term in right-hand side of Equation B1 is negative, since we have shown that $\frac{\partial v_0^{-1}}{\partial \sigma_s} = \frac{\partial d_0^{-1}}{\partial \sigma_s}$ in Equation 12. Therefore, $\frac{\partial d_0^{-1}/\partial \sigma_s}{\partial \lambda}$ is the only term whose sign remains undetermined in the first term in right-hand side of Equation B1

$$\frac{\left(\frac{\partial d_0^{-1}}{\partial \sigma_s}\right)}{\partial \lambda} = \frac{2\sigma_a^2 \gamma^2 \lambda\left(\sigma_a (\gamma\lambda)^2 + \sigma_s \sigma_a^2\right)\left[\sigma_a (\gamma\lambda)^2 - \sigma_s \sigma_a^2\right]}{\left[\sigma_a (\gamma\lambda)^2 + \sigma_s \sigma_a^2\right]^4}$$

We can see that if $\lambda > \lambda^* = \frac{\sqrt{\sigma_s \sigma_a}}{\gamma}$, one has $\sigma_a (\gamma\lambda)^2 - \sigma_s \sigma_a^2 > 0$ and $\frac{\partial d_0^{-1}/\partial \sigma_s}{\partial \lambda} > 0$, it ensures Equation B1 is negative.

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