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Demand Expansion and Price Premium Effects of Marketing Effort: Modeling and Comparative Analysis

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Abstract

In this paper, we compare the outcomes of demand expansion and price premium effects in a dyadic supply chain. We find that in the decentralized setting, the output and effort, as well as the profits of both the manufacturer and the retailer under a demand expansion scenario are lower than that under the price premium scenario. Surprisingly, we find that under both the cases of demand expansion and price premium, the profit of the manufacturer is greater than the profit of the retailer, even though it is only the manufacturer who incurs all the cost.

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1 Introduction

Firms may take actions that can lead to *demand expansion* or a *price premium* effect. For example, product promotion campaigns and quantity discounts stimulate sales leading to a demand expansion effect. On the other hand, brand building advertising leads to a price premium effect. Both these effects involve the expenditure of some efforts, which is costly for a firm. The impact of these efforts is also different on the profit of the firm and other strategic variables. Thus, it is important to understand which of these two efforts would a firm want to invest in, given that both these efforts affect the firm's profit and also involves the use of significant amount of resources. Our analysis is useful from a manufacturer's strategic decision too - should the firm invest in quantity discounts or should it invest in a brand building policy? We attempt to answer this question in this paper.

Faced with increasing competition from private labels, manufacturers of national brands have introduced a price premium for their products. This is despite the fact that a price premium might negatively impact the sales volume. A price premium denotes a higher willingness to pay for the good by the consumer. Examples of manufacturers who have introduced price premiums include Unilever, Kellogg, General Mills etc. (Steenkamp et al. (2010)). As Steenkamp et al. (2010) report, there has been academic research exploring the question of why consumers would want to pay a price premium for the manufacturer's national brand (Sethuraman and Cole, 1999). Price premium is also observed in the case of goods which are produced following environmentally sustainable practices (Sedjo and Swallow, 2002). In addition, consumers are willing to pay a price premium for products which are reputed (Landon and Smith, 1998).

Demand expansion occurs when a firm introduces product promotion to stimulate sales. For example, manufacturers like Xerox use various promotional campaigns to stimulate sales.[1] Beverage giant Coca Cola uses promotions and sustainable practices to boost sales.[2] Raju (1992) has studied the impact of promotions on various brands using data from a major grocery chain and finds that magnitude of discounts increases sales. For a game theoretic analysis of promotions and empirical analysis, refer Rao et al. (1995).

While price premium and demand expansion have been looked at separately in the literature, to the best of our knowledge there is no comparative analysis of the two marketing tools in the context of a supply chain. We attempt to bridge this gap in this paper by analyzing the impact of demand expansion and price premium effect in the context of a dyadic supply chain. In particular, we model a Stackelberg game with the manufacturer being the leader and the retailer being the follower. We begin with the decentralized model under demand expansion and then consider the model with price premium effect. Thereafter, we look at the vertically integrated outcome under both the effects. In our setting, under both demand expansion and price premium, the manufacturer incurs a cost of promotions or brand building advertising. The retailer does not share in any part of the cost of the marketing efforts of the manufacturer. Such an asymmetric cost arrangement leads to the question of why the manufacturer should bear the cost when the benefits of the price premium go to the retailer. Surprisingly, we find that even when the manufacturer incurs all the cost, under both de-

[1] See: https://www.marketingsherpa.com/article/how-to/how-xerox-uses-promo-products.

[2] https://www.marketingweek.com/2015/10/13/coke-life-one-year-on-sales-success-or-marketing-gimmick/

mand expansion and price premium, the profit of the manufacturer is greater than the profit of the retailer. In the industrial organization literature, leader-follower games involving price competition find that the follower gets the second mover advantage (Gal-Or, 1985, Dowrick, 1986). In our scenario, it is first mover (the manufacturer) who earns a higher profit despite incurring the entire cost of the marketing effort. Thus, a change in the structure and context of the conventional leader-follower game (as is done in our setting) changes the result on who gets the advantage.

A second interesting implication of our model is that both the manufacturer and the retailer earn higher profit when the manufacturer undertakes a brand building advertising effort (price premium) as opposed to a promotion effort (demand expansion). That this result holds true for the manufacturer is indeed surprising. In the case of a price premium effect, the retailer gets all the benefit of the price premium. However, this allows the manufacturer to charge a higher wholesale price which does not get passed on to the consumer in the form of a higher retail price (as would be expected in a dyadic supply chain), implying then that the output does not fall. Therefore the profit of the manufacturer is greater when it undertakes a brand building advertising effort as opposed to a product promotion effort. Finally, these observations on profit of the supply chain being greater (under the price premium effect) continue to hold when we look at the vertically integrated outcomes under a demand expansion and a price premium effect.

The remainder of the paper is organized as follows. In section 2, we present the decentralized model under both a demand expansion as well as a price premium effect and compare the outcomes under the two scenarios. Section 3 analogously analyzes both the scenarios under vertical integration. Section 4 concludes. All derivations and proofs are reported in the Appendix.

2 Decentralized Model

We consider a supply chain consisting of a single manufacturer (M) and a single retailer (R). The manufacturer produces the good and supplies it to the retailer, who then finally sells the good to the consumer. We first analyze the decentralized model where the manufacturer's efforts leads to a demand expansion effect. Then we consider a model where the manufacturer's effort leads to a price premium effect for the retailer.

2.1 Demand Expansion (DE)

Suppose that the demand curve is given by $q = \theta - \gamma p + \delta\tau$, where, θ is the market potential, $\gamma > 0$ is the price sensitivity parameter, and $\delta > 0$ is the amplitude of the demand expansion effort. The demand expansion equation is similar to that used in Desai and Srinivasan (1995); Desai (1997); Desai (2000); Swami and Shah (2012), and Ghosh and Shah (2015). The term τ has multiple interpretations - it may generally be called as marketing effort in promotions or discounts, or even greening effort. Investing in these promotions or offering discounts is costly for the firm. Following Savaskan and Van Wassenhove (2006), the cost of demand expansion effort is given by $C(\tau) = \beta\tau^2$, where $\beta > 0$ is a parameter which measures the amplitude of the promotion effort. β can be interpreted as a parameter measuring the inefficiency of the effort. The convex effort function also represents the fact that the marginal cost of promotion is increasing in τ. We assume that the marginal cost of production and the marginal cost of retailing are both constant, and given by c and r respectively. Note that in our framework, only the manufacturer invests in promotion efforts, while the retailer does not. Several examples are consistent with this framework. Companies like Proctor & Gamble, Gillette, L'Oreal issue various discounts and coupons to promote their products and thereby boost sales.[3]

The profit of the manufacturer and the retailer are then given by

$$\Pi_{DE}^{M} = [w - c]q - \beta\tau^2 \qquad \Pi_{DE}^{R} = [p - w - r]q \tag{1}$$

We analyze the following two-stage game:

- **Stage 1:** The manufacturer chooses the wholesale price w and the promotion effort τ to maximize its profit.
- **Stage 2:** The retailer observes (w, τ) and chooses the retail price p to maximize its profit.

The optimal wholesale price and promotion effort in the decentralized scenario is given by (see the Appendix for the detailed derivation)

$$w_{DE} = c + \frac{4\beta[\theta - \gamma(c + r)]}{8\beta\gamma - \delta^2} \qquad \tau_{DE} = \frac{\delta[\theta - \gamma(c + r)]}{8\beta\gamma - \delta^2} \tag{2}$$

and the optimal retail price and demand are given by

$$p_{DE} = c + r + \frac{6\beta[\theta - \gamma(c + r)]}{8\beta\gamma - \delta^2} \qquad q_{DE} = \frac{2\beta\gamma[\theta - \gamma(c + r)]}{8\beta\gamma - \delta^2} \tag{3}$$

Note that for the output to be positive we will impose the restriction $8\beta\gamma > \delta^2$. The optimal profit of the manufacturer and the retailer is then given by

$$\Pi_{DE}^{M} = \frac{\beta[\theta - \gamma(c + r)]^2}{8\beta\gamma - \delta^2} \qquad \Pi_{DE}^{R} = \frac{4\beta^2\gamma[\theta - \gamma(c + r)]^2}{[8\beta\gamma - \delta^2]^2} \tag{4}$$

2.2 Price Premium (PP)

We now consider the case where the manufacturer invests effort in brand building advertising. This allows the retailer to charge a price premium $\alpha\tau$, which is paid by the consumer. For example, when manufacturers like Proctor & Gamble, or Unilever nationally advertise, it allows retailers (who are relatively small) to charge a price premium. For convenience, we assume that the cost function for advertising effort is the same as in the case of demand expansion. Before we solve the decentralized model, we first derive the new demand curve when a price premium effect is present. Since the willingness to pay for the consumer

[3]http://www.marketing91.com/marketing-mix-of-gillette/
http://www.campaignlive.co.uk/article/57258/sales-promotion-p-g-rsquos-gamble-price-promotion

increases by $\alpha\tau$, we denote the new inverse demand curve as $p' = p + \alpha\tau = \frac{\theta - q}{\gamma} + \alpha\tau$, where, $q = \theta - \gamma p$ denotes the baseline demand curve without any price premium. Rearranging the above expression, we have the demand curve under a price premium effect given by $q = \theta + \alpha\gamma\tau - \gamma p'$. Note that when $\alpha\gamma = \delta$, the demand curve under price premium effect and demand expansion effect become identical.

The profit functions of the manufacturer and the retailer are given by

$$\Pi^M_{PP} = [w - c][\theta + \alpha\gamma\tau - \gamma p'] - \beta\tau^2 \qquad \Pi^R_{PP} = [p' - w - r][\theta + \alpha\gamma\tau - \gamma p'] \tag{5}$$

We consider the following two-stage game.

- **Stage 1:** The manufacturer chooses the wholesale price w and the effort τ to maximize its profit.
- **Stage 2:** The retailer observes (w, τ) and chooses p' to maximize its profit.

The optimal wholesale price and advertising effort are given by (see the Appendix for a detailed derivation)

$$w_{PP} = c + \frac{4\beta[\theta - \gamma(c + r)]}{\gamma[8\beta - \alpha^2\gamma]} \qquad \tau_{PP} = \frac{\alpha[\theta - \gamma(c + r)]}{[8\beta - \alpha^2\gamma]} \tag{6}$$

The optimal retail prices and demand can then be written as

$$p'_{PP} = c + r + \frac{6\beta[\theta - \gamma(c + r)]}{[8\beta\gamma - \alpha^2\gamma^2]} \qquad q_{PP} = \frac{2\beta[\theta - \gamma(c + r)]}{8\beta - \alpha^2\gamma} \tag{7}$$

Note that for the output to be positive we will impose the restriction $8\beta\gamma - \alpha^2\gamma^2 > 0$. The optimal profit of the two firms under price premium are

$$\pi^M_{PP} = \frac{\beta[\theta - \gamma(c + r)]^2}{[8\beta\gamma - \alpha^2\gamma^2]} \qquad \pi^R_{PP} = \frac{4\beta^2[\theta - \gamma(c + r)]^2}{\gamma[8\beta - \alpha^2\gamma]^2} \tag{8}$$

It is useful to analyze the impact of α on the retailer's optimal decision variables. Note that greater is α, greater is the effort on brand building advertising and greater is the optimal retail price. To see this note that $\frac{\partial \tau_{PP}}{\partial \alpha} = \frac{[\theta - \gamma(c+r)][8\beta + 3\alpha^2\gamma]}{[8\beta - \alpha^2\gamma]^2} > 0$ and $\frac{\partial p'_{PP}}{\partial \alpha} = \frac{12\alpha\beta[\theta - \gamma(c+r)]}{[8\beta - \alpha^2\gamma]^2} > 0$. Essentially then, even without any demand expansion effect per se, the impact of brand building advertising allows the retailer to increase the optimal retail price, and, not lose sales since $\frac{\partial q_{PP}}{\partial \alpha} = \frac{4\alpha\beta\gamma[\theta - \gamma(c+r)]}{[8\beta - \alpha^2\gamma]^2} > 0$.

2.3 Comparison of Demand Expansion and Price Premium

We want to compare the equilibrium outcomes of the Demand Expansion and the Price premium effect. Proposition 1 formalizes this result.

Proposition 1. *Comparing the demand expansion with the price premium effect, if $\alpha\gamma \gtreqless \delta$, then*

$$w_{DE} \lesseqgtr w_{PP}, \quad \tau_{DE} \lesseqgtr \tau_{PP}, \quad p_{DE} \lesseqgtr p'_{PP}, \quad q_{DE} \lesseqgtr q_{PP}, \quad \Pi^M_{DE} \lesseqgtr \Pi^M_{PP}, \quad \Pi^R_{DE} \lesseqgtr \Pi^R_{PP}$$

In addition, the ratio of the manufacturer profit to the retailer profit is greater under a demand expansion effect as opposed to a price premium effect. If $\alpha\gamma = \delta$, then the outcomes under the demand expansion and the price premium scenarios are identical.

Surprisingly, it follows from Proposition 1 that when $\alpha\gamma > \delta$, the optimal output under a demand expansion effect is lower than the optimal output under a price premium effect, even though the retail price under demand expansion is lower than that under price premium. Figure 1 depicts this outcome. The baseline demand curve is $q = \theta - \gamma p$. With a demand expansion effect, the demand curve shifts by $\delta\tau$ to $q = \theta - \gamma p + \delta\tau$. With a price premium effect, the demand curve shifts to $q = \theta - \gamma p' + \alpha\gamma\tau$. In the case of a price premium effect, the consumer is willing to pay a higher price because the price premium effect generates a sort of product superiority in the consumer's mind.[4] The manufacturer, being the first mover, incorporates the retailer's reaction function into its objective function and optimally charges a higher wholesale price in the case of a price premium effect. The higher wholesale price also gets passed on to the consumer in the form of a higher retail price. Furthermore, note that $q_{PP} > q_{DE}$. The above observations then imply that both the manufacturer and the retailer earn a higher profit in the case of a price premium effect as compared to a demand expansion effect. The outcome of Proposition 1 is graphically expressed in Figure 2.

In addition, Proposition 1 presents one additional interesting finding. Even though the profits of the manufacturer and retailer under a price premium effect are greater than their respective profits under a demand expansion effect, the same finding is no longer valid when we compare the ratio of the manufacturer profit to the retailer profit under the two scenarios. Now it emerges that the ratio of the manufacturer profit to the retailer profit is greater under a demand expansion effect as opposed to a price premium effect. To see this note that

$$\frac{\pi_{DE}^{M}}{\pi_{PP}^{M}} = \frac{8\beta\gamma - \alpha\gamma}{8\beta\gamma - \delta^2} \qquad\qquad \frac{\pi_{DE}^{R}}{\pi_{PP}^{R}} = [\frac{8\beta\gamma - \alpha\gamma}{8\beta\gamma - \delta^2}]^2$$

Since $\alpha\gamma > \delta$, $\frac{8\beta\gamma-\alpha\gamma}{8\beta\gamma-\delta^2} < 1$. Therefore $\frac{\pi_{DE}^{M}}{\pi_{PP}^{M}} > \frac{\pi_{DE}^{R}}{\pi_{PP}^{R}}$. The result then immediately follows by rearranging the terms. The intuition behind this result stems from the fact that a move from demand expansion to price premium effect, increases the retailer's profit by more than that of the manufacturer. Since in both the demand expansion as well as the price premium effect cases, it is the manufacturer who incurs all the cost, a further interesting question to ask is how do the profits of the manufacturer compare with the retailer under both demand expansion and price premium. Proposition 2 addresses this question formally.

Proposition 2. *Under both the demand expansion as well as price premium effect, it follows that the profit of the manufacturer is greater than the profit of the retailer.*

Proposition 2 presents an interesting finding. It is the manufacturer who earns a greater profit in comparison to the retailer, even though the entire cost of product promotion (under demand expansion) or brand building advertising (under price premium) is borne by the manufacturer. Traditional models of sequential price leadership (Gal-Or, 1985) find the second mover advantage. In contrast, in our setting it is the first mover (M) who benefits

[4] We thank an anonymous referee for this comment.

and earns a higher profit. Another interesting observation is that the first mover advantage continues to persist even in the price premium effect scenario. In this scenario, the entire price premium is charged by the retailer, who incurs no additional cost. Nevertheless, it is the manufacturer who earns a higher profit because the presence of the price premium allows the manufacturer to charge a higher wholesale price, knowing fully well that this will not be impacting the sales negatively.

Before we analyze the vertically integrated supply chain, it is important to note that the efforts in our model are deterministic.[5] If the effort (in each case) was uncertain, then it would essentially translate to the demand being stochastic. To see this, suppose that $\tau = \tau' + e$, where τ follows some distribution with cumulative distribution F and density f. Then the demand functions in the case of demand expansion and price premium are, respectively, $q = \theta - \gamma p + \delta\tau' + \delta e$, and $q = \theta - \gamma p' + \alpha\gamma\tau' + \alpha\gamma e$. If $E(e) = 0$, then the optimal solutions are the same as that in the deterministic model. The stochastic demand model introduces uncertainty in the decision making of the players in the chain (Cachon and Lariviere, 2005). Following, He et al. (2009), and Li et al. (2013), it can be conjectured that to compensate for this risk from uncertainty, the stochastic model would lead to lower effort and higher prices compared to the deterministic case. This would then likely imply lower profit for the players.[6]

3 Vertical Integration

In this section, we compare the vertically integrated outcomes for the demand expansion and price premium effect. Obviously, the vertically integrated wholesale and retail prices are lower, effort is higher, and output and profits are higher in comparison to the decentralized scenario. What is not obvious is how the vertically integrated chain performs when we compare the demand expansion and price premium effects. We first state the optimal solutions in the two scenarios for the vertically integrated supply chain.

3.1 Demand Expansion

The VI supply chain chooses p and τ to maximize $\pi_{DE}^{VI} = [p - c - r]q - \beta\tau^2$, where $q = \theta - \gamma p + \delta\tau$. The optimal solutions are

$$p_{DE}^{VI} = c + r + \frac{2\beta[\theta - \gamma(c+r)]}{4\beta\gamma - \delta^2} \qquad \tau_{DE}^{VI} = \frac{\delta[\theta - \gamma(c+r)]}{4\beta\gamma - \delta^2} \tag{9}$$

Therefore the optimal outputs and profit of the chain are

$$q_{DE}^{VI} = \frac{2\beta\gamma[\theta - \gamma(c+r)]}{4\beta\gamma - \delta^2} \qquad \pi_{DE}^{VI} = \frac{\beta[\theta - \gamma(c+r)]^2}{4\beta\gamma - \delta^2} \tag{10}$$

[5]We thank an anonymous referee for this comment.

[6]A more detailed analysis is an interesting avenue for future research.

3.2 Price Premium

Under the price premium effect, the vertically integrated chain chooses p' and τ to maximize $\pi_{PP}^{VI} = [p' - c - r]q - \beta\tau^2$, where $q = \theta - \gamma p' + \alpha\gamma\tau$. The optimal solutions are

$$p'^{VI}_{PP} = c + r + \frac{2\beta[\theta - \gamma(c+r)]}{4\beta\gamma - \alpha^2\gamma^2} \quad \tau^{VI}_{PP} = \frac{\alpha[\theta - \gamma(c+r)]}{4\beta - \alpha^2\gamma} \tag{11}$$

$$q^{VI}_{PP} = \frac{2\beta\gamma[\theta - \gamma(c+r)]}{4\beta\gamma - \alpha^2\gamma^2} \qquad \pi^{VI}_{PP} = \frac{\beta[\theta - \gamma(c+r)]^2}{4\beta\gamma - \alpha^2\gamma^2} \tag{12}$$

Proposition 3 formally states the result of the comparison in the vertically integrated scenario.

Proposition 3. *Comparing the vertically integrated solution under a demand expansion effect with a price premium effect, we have, if $\alpha\gamma \gtrless \delta$, then*

$$p^{VI}_{DE} \lessgtr p'^{VI}_{PP}, \quad q^{VI}_{DE} \lessgtr q^{VI}_{PP}, \quad \tau^{VI}_{DE} \lessgtr \tau^{VI}_{PP}, \quad \pi^{VI}_{DE} \lessgtr \pi^{VI}_{PP}$$

Proposition 3 states that the main findings of the decentralized model continue to hold even when we consider the supply chain to be vertically integrated. The surprising findings are in the fact that under certain parametric conditions, the output and profit of the chain under demand expansion are lower than those under a price premium. The impact of price premium in the decentralized scenario is reinforced in the case of vertical integration.

Because of the presence of the price premium, the retail price p is lower, thereby leading to larger sales. Furthermore, since the effort τ under price premium is larger than that under demand expansion, the net price received, $p + \alpha\tau$ along with larger sales, also imply that profit is higher under the price premium effect.

4 Conclusion

In this paper, we analyze the impact of demand expansion and price premium effects of marketing effort in the context of a dyadic supply chain. The demand expansion effort includes various product promotions and quantity discounts, while the price premium effort is interpreted as brand building advertising. We make the following contributions.

First, we show that in a decentralized setting, the output and marketing effort under a demand expansion scenario is lower than that under a price premium scenario. Moreover, the profits for both the manufacturer and the retailer are greater under price premium effect. Second, we find that the profit of the manufacturer is greater than the profit of the retailer in both the scenarios, even though it is the manufacturer who incurs the entire cost of the marketing effort. Thus our model finds the presence of first mover advantage. Third, we extend the comparison between demand expansion and price premium to the case where the supply chain is vertically integrated. We continue to find that the vertically integrated supply chain profit is greater under price premium.

Firms are constantly faced with the question of what marketing strategies should they adopt to boost their product sales as well as the profitability of their firms - product promotion or brand building advertising. Our analysis suggest that firms may prefer using a brand building advertising strategy to a product promotion strategy, when boosting sales and profits are the main objective. While both strategies unambiguously improve profits, there are greater gains when the brand building advertising strategy is adopted.

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Appendix

$A1$: Derivation of Decentralized Scenario - Demand Expansion

We solve the game backwards starting with the stage 2 game. The first-order necessary condition for the retailer's problem is given by

$$\frac{\partial \Pi_R}{\partial p} = \theta - \gamma p + \delta\tau + [p - w - r](-\gamma) = 0 \tag{13}$$

yielding the following reaction function

$$p(w,\tau) = \frac{\theta + \gamma(w + r) + \delta\tau}{2\gamma} \tag{14}$$

In stage 1, the manufacturer incorporates (14) into its profit function and chooses w and τ. The first-order necessary conditions are

$$\frac{\partial \Pi_M}{\partial w} = \theta - \gamma p(w,\tau) + \delta\tau + [w - c][-\gamma\frac{\partial p(w,\tau)}{\partial w}] = 0 \tag{15}$$

$$\frac{\partial \Pi_M}{\partial \tau} = [w - c][-\gamma\frac{\partial p(w,\tau)}{\partial \tau} + \delta] - 2\beta\tau = 0 \tag{16}$$

yielding the following reaction functions

$$w(\tau) = \frac{\theta + \gamma(c - r) + \delta\tau}{2\gamma} \tag{17}$$

$$t(w) = \frac{\delta[w - c]}{4\beta} \tag{18}$$

Solving (17) and (18), the optimal wholesale price and the promotion effort are given by

$$w_{DE} = c + \frac{4\beta[\theta - \gamma(c + r)]}{8\beta\gamma - \delta^2} \tag{19}$$

$$\tau_{DE} = \frac{\delta[\theta - \gamma(c + r)]}{8\beta\gamma - \delta^2} \tag{20}$$

Substituting (19) and (20) into (14) and the demand function, the optimal retail price and demand are given by

$$p_{DE} = c + r + \frac{6\beta[\theta - \gamma(c + r)]}{8\beta\gamma - \delta^2} \tag{21}$$

$$q_{DE} = \frac{2\beta\gamma[\theta - \gamma(c + r)]}{8\beta\gamma - \delta^2} \tag{22}$$

The optimal profit of the manufacturer and the retailer is then given by

$$\Pi^M_{DE} = \frac{\beta[\theta - \gamma(c + r)]^2}{8\beta\gamma - \delta^2} \qquad \Pi^R_{DE} = \frac{4\beta^2\gamma[\theta - \gamma(c + r)]^2}{[8\beta\gamma - \delta^2]^2}$$

$A2$: Derivation of Decentralized Scenario - Price Premium
We start with the retailer's problem. The first-order condition is

$$\frac{\partial \pi_{PP}^R}{\partial p'} = \theta - 2\gamma p' + \alpha\gamma\tau + \gamma w + \gamma r = 0 \tag{23}$$

yielding the following reaction function

$$p'(w,\tau) = \frac{\theta + \gamma[w + r + \alpha\tau]}{2\gamma} \tag{24}$$

In stage 1, the manufacturer incorporates (24) into its profit function and chooses the wholesale prices w, and the effort τ to maximize its profit. The first-order necessary conditions are

$$\frac{\partial \pi_{PP}^M}{\partial w} = [w - c][-\gamma\frac{\partial p'(w,\tau)}{\partial w}] + \theta + \alpha\gamma\tau - \gamma p'(w,\tau) = 0 \tag{25}$$

$$\frac{\partial \pi_{PP}^M}{\partial \tau} = [w - c][\alpha\gamma - \gamma\frac{\partial p'(w,\tau)}{\partial \tau}] - 2\beta\tau = 0 \tag{26}$$

yielding the following reaction functions

$$w(\tau) = \frac{\theta - \gamma[r - c - \alpha\tau]}{2\gamma} \tag{27}$$

$$\tau(w) = \frac{[w - c]\alpha\gamma}{4\beta} \tag{28}$$

Solving (27) and (28) yields the optimal wholesale price and the effort as

$$w_{PP} = c + \frac{4\beta[\theta - \gamma(c + r)]}{\gamma[8\beta - \alpha^2\gamma]} \tag{29}$$

$$\tau_{PP} = \frac{\alpha[\theta - \gamma(c + r)]}{[8\beta - \alpha^2\gamma]} \tag{30}$$

The optimal retail prices and demand can then be written as

$$p'_{PP} = c + r + \frac{6\beta[\theta - \gamma(c + r)]}{\gamma[8\beta - \alpha^2\gamma]} \tag{31}$$

$$q_{PP} = \frac{2\beta[\theta - \gamma(c + r)]}{8\beta - \alpha^2\gamma} \tag{32}$$

The optimal profit of the two firms under price premium are

$$\pi_{PP}^M = \frac{\beta[\theta - \gamma(c + r)]^2}{[8\beta\gamma - \alpha^2\gamma^2]} \qquad \pi_{PP}^R = \frac{4\beta^2[\theta - \gamma(c + r)]^2}{\gamma[8\beta - \alpha^2\gamma]^2} \tag{33}$$

$A3$: Proof of Proposition 1: The proof follows directly by comparing the optimal values under the two scenarios. To see this note that

$$\begin{aligned}
w_{DE} - w_{PP} &= -\frac{4\beta[\alpha\gamma + \delta][\alpha\gamma - \delta][\theta - \gamma(c+r)]}{[8\beta\gamma - \alpha^2\gamma^2][8\beta\gamma - \delta^2]} < 0 \\
\tau_{DE} - \tau_{PP} &= -\frac{\gamma[8\beta + \alpha\delta][\alpha\gamma - \delta][\theta - \gamma(c+r)]}{[8\beta\gamma - \alpha^2\gamma^2][8\beta\gamma - \delta^2]} < 0 \\
p_{DE} - p'_{PP} &= -\frac{6\beta\alpha\gamma + \delta][\alpha\gamma - \delta][\theta - \gamma(c+r)]}{[8\beta\gamma - \alpha^2\gamma^2][8\beta\gamma - \delta^2]} < 0 \\
q_{DE} - q_{PP} &= -\frac{2\beta\gamma[\alpha\gamma + \delta][\alpha\gamma - \delta][\theta - \gamma(c+r)]}{[8\beta\gamma - \alpha^2\gamma^2][8\beta\gamma - \delta^2]} < 0 \\
\Pi^M_{DE} - \Pi^M_{PP} &= -\frac{\beta[\alpha\gamma + \delta][\alpha\gamma - \delta][\theta - \gamma(c+r)]^2}{[8\beta\gamma - \alpha^2\gamma^2][8\beta\gamma - \delta^2]} < 0 \\
\Pi^R_{DE} - \Pi^R_{PP} &= -\frac{4\beta^2\gamma[\alpha\gamma + \delta][\alpha\gamma - \delta][16\beta\gamma - \alpha^2\gamma^2 - \delta^2][\theta - \gamma(c+r)]^2}{[8\beta\gamma - \alpha^2\gamma^2][8\beta\gamma - \delta^2]} < 0
\end{aligned}$$

To the see that the ratio of manufacturer profit to retailer profit under demand expansion is greater than than under price premium, note that

$$\frac{(\frac{\pi^M_{DE}}{\pi^R_{DE}})}{(\frac{\pi^M_{PP}}{\pi^R_{PP}})} = \frac{8\beta\gamma - \delta^2}{8\beta\gamma - \alpha^2\gamma^2}$$

Now, $(\frac{\pi^M_{DE}}{\pi^R_{DE}}) > (\frac{\pi^M_{PP}}{\pi^R_{PP}})$, iff, $\frac{8\beta\gamma - \delta^2}{8\beta\gamma - \alpha^2\gamma^2} > 1$; which occurs if $\alpha > \frac{\delta}{\gamma}$, which is true.

***A*3: Proof of Proposition 2:**

From the optimal solutions, we have

$$\pi^M_{DE} - \pi^R_{DE} = \frac{\beta[\theta - \gamma(c+r)]^2[4\beta\gamma - \delta^2]}{[8\beta\gamma - \delta^2]^2} > 0.$$

Similarly,

$$\pi^M_{PP} - \pi^R_{PP} = \frac{\beta[\theta - \gamma(c+r)]^2[4\beta\gamma - \alpha^2\gamma^2]}{[8\beta\gamma - \alpha^2\gamma^2]^2} > 0.$$

***A*4: Proof of Proposition 3:**

The proof follows by comparing the optimal solutions under vertical integration in the

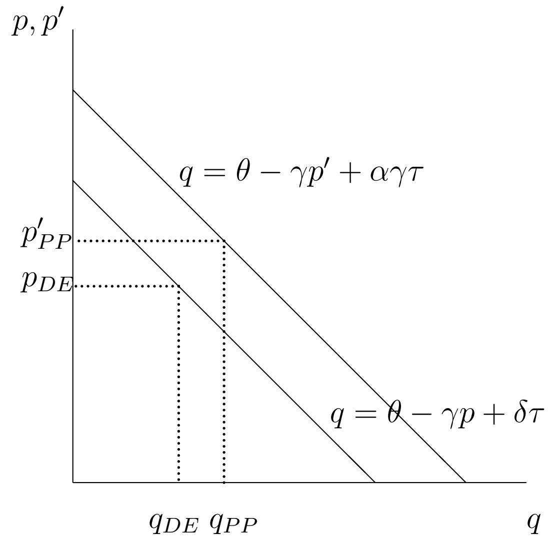

Figure 1: Demand Expansion and Price Premium Comparison

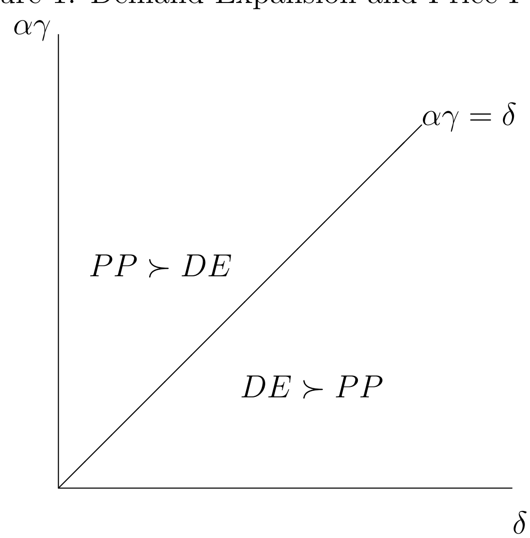

Figure 2: Preferred Regions for Demand Expansion and Price Premium.

two scenarios. Formally,

$$\begin{aligned}
p_{DE}^{VI} - p_{PP}^{\prime VI} &= -\frac{2\beta[\alpha\gamma+\delta][\alpha\gamma-\delta][\theta-\gamma(c+r)]}{[4\beta\gamma-\alpha^2\gamma^2][4\beta\gamma-\delta^2]} < 0 \\
q_{DE}^{VI} - q_{PP}^{VI} &= -\frac{2\beta\gamma[\alpha\gamma+\delta][\alpha\gamma-\delta][\theta-\gamma(c+r)]}{[4\beta\gamma-\alpha^2\gamma^2][4\beta\gamma-\delta^2]} < 0 \\
\tau_{DE}^{VI} - \tau_{PP}^{VI} &= -\frac{\gamma[\alpha\gamma-\delta][4\beta+\alpha\delta][\theta-\gamma(c+r)]}{[4\beta\gamma-\alpha^2\gamma^2][4\beta\gamma-\delta^2]} < 0 \\
\pi_{DE}^{VI} - \pi_{PP}^{VI} &= -\frac{\beta[\alpha\gamma+\delta][\alpha\gamma-\delta][\theta-\gamma(c+r)]^2}{[4\beta\gamma-\alpha^2\gamma^2][4\beta\gamma-\delta^2]} < 0
\end{aligned}$$