

# Buyer Market Power and Vertically Differentiated Retailers in the Food Supply Chain

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## Abstract

We consider a model of vertical competition where downstream firms (retailers) purchase an upstream input from a monopolist and are able to differentiate from each other in terms of quality. Our primary focus is to study the effects of introducing a retailer that is able to push wholesale prices down (i.e. buyer market power). Consistent with recent efforts by traditional retailers to enhance shoppers' buying experience (i.e. quality), we find that the large retailer offers a low-quality/low-price product, whereas the traditional retailer (i.e. the store with no buyer market power) offers a high-quality/high-price product. Compared to the case of no buyer market power, we find that consumer welfare increases for two different reasons. First, consumers gain from the large retailer's low price (since the upstream discount is partially passed on to the retail price) as well as from the high quality level offered by the traditional retailer. However, contrary to conventional wisdom, most of the consumer welfare gains seem to be due to the latter. The intuition for this result is that price competition softens substantially as a result of firms' quality differentiation. We also investigate the effects of buyer market power on retail and wholesale prices as well as on producer welfare.

**Keywords:** buyer market power, vertical differentiation, Wal-Mart

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## 1. Introduction

For decades, researchers and policy makers have been concerned with the negative effects of imperfect markets in the food industry. Most of the attention has focused on *seller* concentration and its association with higher prices, reduced consumer surplus, and larger profits. Under this “unidirectional” market power approach, downstream agents (buyers) play a passive role by accepting the price set by upstream firms. However, recent concentration trends in downstream markets (i.e. food processors and retailers) require a closer look at the existence and effects of *buyer* market power; ignoring bidirectional market power can produce biased results when studying, for example, how welfare is affected by mergers or by the presence of large retail chains.<sup>1</sup>

Unlike other inputs such as energy, oil or labor, agricultural products are either purchased in raw form by final consumers or are transformed (processed) in some way. These characteristics make buyer market power especially relevant in agricultural markets. For example, agricultural products are often sold to a handful of firms that specialize in processing it; this is notably reflected by the consolidation of food processors as buyers of farmers’ outputs. In addition, a large fraction of fresh produce output is channeled through large and increasingly dominant retail chains: in 2005 food sales by the four largest retailers at the *national* level was 35.5% while food sales by the four largest retailers in a *local* metropolitan area was, on average, 72.3% (ERS, 2000; 2009).<sup>2</sup> Importantly, mass merchandisers (e.g. Wal-Mart, Target and Kmart) and warehouse clubs (e.g. Costco and Sam’s) are capturing an ever larger share of all food retail sales in the U.S. Among these merchandisers, Wal-Mart can be a particularly pivotal buyer to

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<sup>1</sup> The two most commonly used terms in the literature are *buyer market power* and *countervailing market power*. We employ the former as it is more intuitive when referring to a buyer’s ability to push upstream prices down (whether it emerges from lack of competition among buyers or simply because the seller has an inherent superior “negotiating” ability). In this paper we assume there is buyer market power, without seeking to explain its existence.

<sup>2</sup> The second figure (72.3%) corresponds to 1998.

food manufacturers. Notable examples in the food industry are Procter & Gamble, Heinz, and Kraft, who earn at least 10 percent of their annual revenue from sales to Wal-Mart (Hopkins, 2003).

Being the largest retailer in the United States, Wal-Mart's 2008 revenues were more than the total combined revenues of the next six U.S. retailers (Kroger, Costco, Home Depot, Target, Walgreen, and CVS Caremark; Schultz, 2009). Among other things, Wal-Mart is known for its low prices: 8-27% lower than conventional retailers (Hausman and Leibtag, 2007), 6-7% lower for national brands and 17% lower for dairy products (Volpe and Lavoie, 2008).<sup>3</sup> In response to Wal-Mart's presence, competing supermarkets have tended to increase the quality of the shopping experience by including amenities such as delis, on-site bakeries, coffee shops, gas stations, banks, pharmacies etc. (Volpe and Lavoie, 2008) as well as introducing high-end private-label brands.<sup>4</sup> After years of decline brought on by fighting Wal-Mart on price, supermarkets appear to be finding a way to win shoppers back by "*sharpening their difference with Wal-Mart's price-obsessed supercenters, stressing less-hectic stores with exotic or difficult-to-match products and greater convenience*" (McWilliams, 2007).

In this paper, we develop a model to study the effects of the presence of a large retailer with buyer market power. Specifically, we consider a simple wholesaler-retailer relationship where retailers buy from a monopolist wholesaler and then sell it (without processing) to final consumers. We consider two main scenarios: the one with two conventional retailers (i.e. no buyer market power) and the other with one large retailer that has buyer market power and one

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<sup>3</sup> Other effects of Wal-Mart's presence are discussed by Basker (2007) and references therein.

<sup>4</sup> A recent study by Bonanno and Lopez (2009) also shows that retailers differentiate themselves from competitors and attract less price-sensitive consumers by service competition in fluid milk markets.

conventional retailer.<sup>5</sup> In our model, buyer market power is measured by an (exogenous) discount rate negotiated between the wholesaler and the retailer. As opposed to earlier work, a key component of our model is that it allows downstream firms to compete not only on prices but also on quality: retailers can choose a different level of “service” (i.e., quality of the shopping experience).

We evaluate the effect of the presence of the large retailer on: 1) consumer welfare and producer welfare, and 2) the price and quantity equilibrium levels. In the absence of a large retailer, conventional retailers set their quality at the same level and compete with each other in a standard Bertrand fashion. Though the profits for both retailers are zero, the wholesaler (as well as consumers) benefit from the intense price competition between retailers. In the presence of a large retailer, conversely, the degree of quality differentiation depends on the size of the discount (i.e. market power) obtained by the retailer: as the discount gets large, the large retailer has a higher incentive to lower prices and a decreased incentive to increase quality; on the other hand, the conventional retailer responds by offering a high quality-high priced product.

We find that consumer welfare increases because (some) consumers with a strong preference for quality benefit from the high-quality/high-price combination offered by the conventional retailer, whereas (some) consumers with a weak preference for quality benefit from low-quality/low-price combination offered by the large retailer. However, the first effect is much larger, suggesting that increases in consumer welfare stemming from lower prices might be smaller than usually claimed. A second finding is that producer welfare also increases in the presence of a large retailer. The main reason for this is that the presence of a large retailer allows

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<sup>5</sup> Given the common association of Wal-Mart with low-prices, the “large retailer” that can negotiate lower prices with suppliers in our theoretical model will be often referred to as “Wal-Mart”.

the wholesaler to reap the benefits of price discrimination between the two retailers. Importantly, producer welfare gains are larger than consumer welfare gains.

The paper is organized as follows. We briefly discuss prior work related to our research in section 2. The model and the main results are presented in section 3. Section 4 presents robustness checks of our model and section 5 provides concluding remarks, limitations and suggestions for further research.

## **2. Literature Review**

There are several prior studies on buyer market power, with different focus (i.e. empirical vs. theoretical) as well as with different research scopes; however, there have been very few attempts to incorporate product differentiation in the analysis.

An issue related to our work that has been analyzed conceptually is whether increased buyer market power by a downstream firm translates into a lower price for the final good. The canonical model considers bilateral market power with a single manufacturer bargaining with competing retailers over the price of a homogeneous good. Dobson and Waterson (1997) and von Ungern-Sternberg (1996) show that, contrary to conventional wisdom, retail prices can sometimes increase (and welfare decrease) with retailer concentration. Chen (2003) assumes a dominant firm structure in the retail market and shows that as the bargaining power of the retailer increases, consumers face lower retail prices.

Erutku (2005) relaxes the assumption of a homogeneous product sold by retailers by assuming a degree of substitutability between a national retailer's good and the same good sold by a local retailer. Results of the model are ambiguous as retail prices may increase or decrease with the degree of buyer market power by the national retailers. Brekke and Straume (2004) also study horizontal product differentiation in the context of bilateral monopoly. Their approach,

however, is to study how bargaining affects the degree of product differentiation downstream and find that downstream firms increase product heterogeneity as the supplier's bargaining power increases.

### 3. Model

We adopt a three-stage game: in stage 1, retailers select the level of service (quality) to provide. In stage 2, the wholesale price to each retailer is determined either through a manufacturer's take-it-or-leave-it offer if the retailer has no buyer market power or through bargaining between the manufacturer and retailer. As a result, the wholesale price depends on the degree of the retailer's buyer market power. In stage 3, retailers compete and simultaneously set retail prices to consumers.

#### 3.1 Setup

In this section we model the wholesaler-retailer relationship where retailers buy products from a wholesaler and sell them to the final consumers. Consider one manufacturer with (seller) market power selling an identical product to two retailers who compete in prices. Retailers are differentiated in the level of service they provide to consumers, i.e., quality of the shopping experience. We model this vertical differentiation à la Mussa and Rosen (1978). Consumers are heterogeneous in their valuation of quality given by  $\theta$ . The conditional indirect utility of a consumer with a marginal willingness to pay  $\theta$  for quality  $k$  and income  $y$  is given by  $y + \theta k - p$  if one unit of the product of quality  $k$  is purchased at price  $p$ , and by  $y$  if the differentiated product is not purchased. We assume a continuum of consumers with total mass of one distributed uniformly and  $\theta \in U[0,1]$ .

Let  $\theta_L$  denote the consumer who is indifferent between buying the low-quality product and not buying the differentiated product, where the subscript  $L$  denotes the low-quality

product.<sup>6</sup> Thus,  $\theta_L$  is the value of  $\theta$  that solves  $y + \theta k_L - p_L = y$ . Similarly,  $\theta_H$  is the consumer that is indifferent between buying the low- or high-quality product, i.e.,  $\theta_H$  is the value of  $\theta$  that solves  $y + \theta k_H - p_H = y + \theta k_L - p_L$ , where the subscript  $H$  denotes the high-quality product. Thus, consumers with  $\theta \in [0, \theta_L)$  will not buy the differentiated product, those with  $\theta \in [\theta_L, \theta_H]$  will buy the low-quality product and the others  $\theta \in (\theta_H, 1]$  will buy the high-quality product. Accordingly, the demand for each quality is the length of the consumer interval buying the given quality multiplied by the density of consumers along that interval times the total number of consumers,  $N=1$ , for illustration convenience. As a result, the demands for the low- and high-quality products are:

$$D_L(p_H, p_L, k_H, k_L) = \theta_H - \theta_L = \frac{p_H k_L - p_L k_H}{k_L(k_H - k_L)}, \quad (1)$$

$$D_H(p_H, p_L, k_H, k_L) = 1 - \theta_H = 1 - \frac{p_H - p_L}{k_H - k_L}. \quad (2)$$

We consider a three-stage game. In stage 1, retailers select  $k_H$  and  $k_L$ , the levels of service (quality) to provide. In stage 2, the wholesale price ( $w$ ) to each retailer is determined either through a manufacturer's (or wholesaler's) take-it-or-leave-it offer if the retailer has no buyer market power or through bargaining between the manufacturer and retailer. In stage 3, retailers simultaneously set  $p_H$  and  $p_L$ . The subgame perfect equilibrium is solved by backward induction.

In this model, Wal-Mart (i.e. the large retailer) has market power and can obtain a discount  $\gamma \in (0, 1)$  on the wholesale price,  $w$ . The size of the discount is determined through bargaining, which is assumed to be exogenous to the problem (as in Erutku, 2005). The larger is  $\gamma$ , the larger is the bargaining (i.e. buyer) power of Wal-Mart. This formulation allows us to

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<sup>6</sup> Low- (high-) quality product refers to a good purchased at a retailer with low- (high-) quality shopping experience as mentioned previously.

nest two scenarios: scenario 1 where both retailers get no discount and scenario 2 where Wal-Mart gets a positive discount. The maximization problem of the retailers (stage 3) can be expressed as:

$$\begin{aligned} \max_{p_H} \pi_H &= (p_H - w) D_H(p_H, p_L, k_H, k_L) - C_H(k_H), \\ \max_{p_L} \pi_L &= (p_L - (1 - \gamma)w) D_L(p_H, p_L, k_H, k_L) - C_L(k_L), \end{aligned}$$

where  $\pi$  denotes profit and  $C(\bullet)$  is the cost of quality improvement.  $\gamma=0$  when the low-quality retailer is a conventional supermarket (scenario 1), and  $\gamma>0$  when the low-quality retailer is Wal-Mart (scenario 2). This formulation assumes that the retailer incurs only the costs of buying the product from the manufacturer and its quality improvement. The quality improvement cost function is assumed to be cubic<sup>7</sup> and that it does not vary with the quantity of products being sold. It is represented by  $c_i(k_i - k_{0i})^3 / 3$ ,  $i=L, H$ , where  $k_{0i}$  is the minimum quality level and the coefficient  $c_L \geq c_H$  captures the efficiency of quality improvement. That is, the high-quality retailer incurs smaller marginal cost of quality improvement than the low-quality retailer. To facilitate the derivation of our model, we further assume that the coefficient of the quality improvement cost for the high-quality retailer,  $c_H$ , and minimum quality level  $k_{0i}$  are normalized to 1.<sup>8</sup> Substituting the demand and cost expressions into the profit functions, we have

$$\begin{aligned} \pi_H &= (p_H - w) \left[ 1 - \frac{p_H - p_L}{k_H - k_L} \right] - \frac{(k_H - 1)^3}{3}, \\ \pi_L &= (p_L - (1 - \gamma)w) \left[ \frac{p_H k_L - p_L k_H}{k_L (k_H - k_L)} \right] - \frac{c_L (k_L - 1)^3}{3}. \end{aligned}$$

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<sup>7</sup> We employ a cubic cost function because alternatives (such as a quadratic setting) involve too many corner solutions. The cubic cost function also provides the necessary convexity. The cost functional form plays an important role in determining the equilibrium; however, the qualitative properties of our conclusions, discussed in section 4, are robust to other cost specifications.

<sup>8</sup> The parameters  $k_{0L}$  and  $k_{0H}$  can be different and not necessarily equal to 1; we use this normalization because it allows an easier comparison between scenarios 1 and 2, and it makes the computation of  $k_L$  and  $k_H$  more tractable.

Taking the first-order condition on price for each retailer and solving for the retail prices we obtain

$$p_H(w, k_H, k_L; \gamma) = \frac{k_H(2k_H - 2k_L + w(3 - \gamma))}{4k_H - k_L}, \quad p_L(w, k_H, k_L; \gamma) = \frac{k_H(k_L + 2w(1 - \gamma)) - k_L(k_L - w)}{4k_H - k_L}.$$

These prices can be substituted into the retailers' demands (equations 1 and 2) to find the aggregate demand for the manufacturer. That is,

$$D_H(w, k_H, k_L; \gamma) = \frac{2k_H(k_H - k_L) - w(k_H + \gamma k_H - k_L)}{(k_H - k_L)(4k_H - k_L)},$$

$$D_L(w, k_H, k_L; \gamma) = \frac{k_H k_L(k_H - k_L) - w k_H(2k_H - 2k_L - 2\gamma k_H + \gamma k_L)}{(k_H - k_L)(4k_H - k_L)k_L}.$$

The manufacturer maximizes profits from sales to the low-quality retailer (at a discount or not) and from sales to the high-quality retailer by choosing  $w$  (stage 2). This maximization problem can be expressed as:

$$\max_w \pi_M = (1 - \gamma)w \frac{2k_H(k_H - k_L) - w(k_H + \gamma k_H - k_L)}{(k_H - k_L)(4k_H - k_L)} + w \frac{k_H k_L(k_H - k_L) - w k_H(2k_H - 2k_L - 2\gamma k_H + \gamma k_L)}{(k_H - k_L)(4k_H - k_L)k_L}.$$

This formulation assumes that the manufacturer does not incur costs. It is straightforward to relax this assumption later. From this maximization problem we obtain the manufacturer's price given by  $w(k_H, k_L; \gamma)$ ,

$$w(k_H, k_L; \gamma) = \frac{k_H k_L(k_H - k_L)(3 - \gamma)}{4k_H^2(1 - \gamma)^2 - 2k_H k_L(1 - 4\gamma + \gamma^2) - 2k_L^2}, \quad (3)$$

which can be substituted back into the retail demands and prices to solve for the optimal quality choices by both retailers. The maximization problem of retailers in stage 1 corresponds to

$$\max_{k_H} \pi_H = \left[ \frac{k_H(2k_H - 2k_L + w(3 - \gamma))}{4k_H - k_L} - w \right] \left[ \frac{2k_H(k_H - k_L) - w(k_H + \gamma k_H - k_L)}{(k_H - k_L)(4k_H - k_L)} \right] - \frac{(k_H - 1)^3}{3}, \quad (4)$$

$$\max_{k_L} \pi_L = \left[ \frac{k_H(k_L + 2w(1-\gamma)) - k_L(k_L - w)}{4k_H - k_L} - (1-\gamma)w \right] \bullet \left[ \frac{k_H k_L (k_H - k_L) - w k_H (2k_H - 2k_L - 2\gamma k_H + \gamma k_L)}{(k_H - k_L)(4k_H - k_L)k_L} \right] - \frac{c_L(k_L - 1)^3}{3}, \quad (5)$$

where  $w$  is defined in equation (3). From (4) and (5) we obtain the equilibrium quality, and thus equilibrium prices and quantities. This stage of the model is solved with numerical methods given the non-linearity of the expressions.

By solving equations (4) and (5), we can see that the optimal levels of  $k_L$  and  $k_H$  are functions of  $\gamma$  and  $c_L$ . That is, in addition to the low-quality retailer's coefficient of quality improvement cost ( $c_L$ ), the optimal quality levels also depend on the discount rate  $\gamma$ , which is the measure of buyer market power. Therefore, varying  $\gamma$  from 0 (a conventional supermarket with no bargaining power) to a positive number (Wal-Mart has a superior bargaining position against a manufacturer) allows us to evaluate the effect of buyer market power on prices, quality levels, and welfare.

In the simulation, we first assume the low-quality retailer's coefficient of quality improvement cost is equal to one ( $c_L = 1$ ) and vary the discount rate  $\gamma$  from 0 to 1 by 0.1 increments. For comparison purposes, we also consider a "base case" where there is only a conventional retailer in the market (next section, 3.2). In the following subsections (3.3 and 3.4) we discuss the two-retailer cases: scenario 1 ( $\gamma = 0$ ) and scenario 2 ( $\gamma \in [0.1, 1]$ ), respectively. Table 1 shows the corresponding results of the base case (2<sup>nd</sup> row), scenario 1 (4<sup>th</sup> row) and scenario 2 (5<sup>th</sup> row onwards).

### 3.2 Base Case: One Conventional Store

When there is one conventional retailer in the market, the maximization problems of the retailer and the manufacturer can be written, respectively, as:

$$\pi_B = (p_B - w)(1 - \theta_B) - \frac{(k_B - 1)^3}{3} = (p_B - w) \left(1 - \frac{p_B}{k_B}\right) - \frac{(k_B - 1)^3}{3},$$

$$\pi_M = w(1 - \theta_B) = w \left(1 - \frac{p_B}{k_B}\right),$$

where the subscript  $B$  stands for the base case and the coefficient of quality improvement cost ( $c$ ) is assumed to be 1. The corresponding equilibrium is given by:

$$k_B = \frac{5}{4}, \quad w = \frac{k_B}{2} = \frac{5}{8}, \quad p_B = \frac{k_B + w}{2} = \frac{15}{16}, \quad \theta_B = \frac{p_B}{k_B} = \frac{3}{4}, \quad D_B = 1 - \theta_B = \frac{1}{4}, \quad \pi_B = \frac{7}{96}, \quad \pi_{MB} = \frac{5}{32}$$

The second row of table 1 displays these results. As it can be seen, quality is above the minimum level ( $k_B=1.25 > k_{0B}=1$ ), whereas the retail price is 50% larger than the wholesale price (0.9375 vs. 0.625). Only 25% of the market and most of society's welfare is captured by firms (0.2292 out of 0.2682) with most of firms' surplus going to the manufacturer (0.1563 out of 0.2292).

### 3.3 Scenario 1: Two Conventional Stores: $\gamma = 0$

When there are two conventional stores in the market, we assume that retailers receive no discount from the manufacturer, i.e.,  $\gamma = 0$ . Table 1 (row 4) shows that both conventional retailers set their quality at the same level ( $k_H = k_L = k^* = 1.0004$ ) and compete with each other in a standard Bertrand fashion ( $w = k^* / 2 \approx p_H = p_L$ ).<sup>9</sup> Since both retailers operate at the same quality level, we cannot label low- and high- quality retailers, but we still refer to them as  $L$  and  $H$  for notational convenience. Market demand is 0.5, which is split equally between two retailers.

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<sup>9</sup> The retailer prices ( $p_L$  and  $p_H$ ) are actually slightly above the wholesale price ( $w$ ) so that retailers can cover the small quality improvement cost; the difference between  $w$  and  $p_i$  is very small and thus can not be seen in Table 1.

There remains an interesting question in stage 1: Why do both retailers set their quality level higher than 1 given that they receive zero profits after all? That is, why do they want to improve their quality? To answer this question, let us look at a payoff matrix in figure 1 for the corresponding strategies in stage 1. Given that the competitor chooses not to improve quality, the retailer's best response is to improve its own quality; conversely, if the competitor decides to improve quality, the retailer is indifferent between improving and not improving quality. Therefore,  $(k_L > 1, k_H > 1)$  are weakly dominant strategies, implying that both retailers slightly improve their quality (from 1 to 1.0004) in stage 1. While profits are still zero when retailers switch from  $(k_L = 1, k_H = 1)$  to  $(k_L > 1, k_H > 1)$ , the wholesaler and consumers benefit from this quality improvement. Specifically, when  $k_L = k_H = 1.0004$  instead of  $k_L = k_H = 1$ , wholesaler's profits are 0.2501 instead of 0.25 and the consumer surplus is 0.1251 instead of 0.125.

Comparing scenario 1 with the base case, we find that quality level, wholesale and retail prices decrease, while market demand doubles (from 0.25 to 0.5). In addition, consumer surplus and wholesaler profits increase while total retailer profits decreases. The total welfare gains stem entirely from increased retailer competition on prices. One can think of this result as an analogue to the standard double marginalization problem (without quality competition): a lower degree of market power in a stage of the supply chain (in this case the retail level) reduces the double marginalization problem thereby increasing overall profits and consumer surplus. This comparison suggests that the entry of a conventional retailer to a market currently being served by a similar (conventional) store will trigger intense price competition (and virtually no quality competition) thereby unambiguously benefiting consumers.

### 3.4 Scenario 2: One Conventional Store and One “Wal-Mart” Store: $\gamma > 0$

In scenario 2, retailer  $L$  is replaced by a low quality retailer that has access to a positive discount  $\gamma > 0$  (e.g. Wal-Mart). In table 1 (rows 5 through 14) we report results for  $\gamma \in [0.1, 1]$  in 0.1 intervals. For the time being, we remain silent about the discount size that a large retailer like Wal-Mart is likely to get in actual negotiations and focus on describing the main results for the analyzed  $[0.1, 1]$  range.<sup>10</sup> Results in table 1 lead to several important observations.

The quality level set by the low-quality retailer has an interesting pattern (figure 2). When the discount rate obtained from the wholesaler is small ( $\gamma = 0.1$ ), Compared to scenario 1, Wal-Mart has an incentive to increase its quality ( $k_L = 1.0441 > 1.0004$ ) and to charge higher prices ( $p_L = 0.5823 > 0.5002$ ). As the discount rate gets larger, Wal-Mart finds it more effective to attract customers through a lower price (for  $\gamma > 0.3$  Wal-Mart’s price is lower than in scenario 1, see figure 3) rather than by improving its quality ( $k_L = 1$  for all  $\gamma \in [0.2, 1]$ ). Intuitively, for a large enough discount rate (i.e.  $\gamma > 0.1$ ) the profitability incentive to offer low prices overcomes the profitability incentive to attract customers via high quality.

In response to Wal-Mart’s low price policy, the high-quality retailer chooses to differentiate its product/service by significantly improving the quality level above that observed in scenario 1 ( $k_H > 1.2$  for all  $\gamma \in [0.1, 1]$ , see figure 2), although not always above the quality level of 1.25 observed in the base case. Intuitively, because of its inability to obtain a discount, the conventional retailer is at a disadvantage when trying to compete in prices with Wal-Mart; instead it chooses to augment its profitability by increasing its quality level.

All prices (wholesale,  $w$ , as well as retail,  $p_L$  and  $p_H$ ) exhibit a non-monotonic relationship with the discount rate  $\gamma$  (see figure 3). The initial price increases are due to the

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<sup>10</sup> In section 3.5 we provide a discussion about the reasonable discount rate for Wal-Mart.

initial intense quality competition that retailers engage in: a relatively small bargaining power by the low-quality retailer makes both firms focus their competition on (higher) quality which results in higher equilibrium prices. Conversely, as larger discount rates are achieved prices tend to fall because: a) the quality levels offered by firms tends to drop (figure 2)<sup>11</sup>, and b) all prices inevitably experience intense downward pressure by Wal-Mart's low price policy. Importantly, for  $\gamma > 0.3$  consumers shopping at the low-quality retailer pay lower prices than in scenario 1, whereas for  $\gamma > 0.5$  *all* consumers pay a lower price than in scenario 1.

It is interesting to point out that a portion of the purchase discount for the low-quality retailer is always passed on to consumers; this can be seen in figure 3:  $p_L < w$ , which implies that the fraction  $(w - p_L)/\gamma w$  of the discount  $\gamma w$  is passed on to consumers (figure 4). The pass-through rate,  $(w - p_L)/\gamma w$ , is decreasing in  $\gamma$ , which implies that more buyer market power allows the low-quality retailer to retain a larger fraction of the discount (and therefore enjoy more profits). Consistently, the markup of the low-quality retailer,  $p_L - (1 - \gamma)w$ , is increasing in  $\gamma$ .

Market demand is  $D_L + D_H = 1 - \theta_L$  and increasing in the discount rate when  $\gamma \in [0.3, 1]$  (figure 5).<sup>12</sup> However, compared with scenario 1, it is not until  $\gamma = 0.4$  that more consumers join the market; in other words, customers with a lower valuations for quality are able to join the market only if Wal-Mart is able to get a sufficiently high discount rate from the supplier. Accordingly, it is not until  $\gamma = 0.4$  that the low-quality retailer sells more than the high-quality retailer. In general, all consumers (low quality as well as high quality purchasers) tend to gain

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<sup>11</sup> Except for  $k_H$  in the  $\gamma \in [0.8, 1]$  range. In general, our model implies that lower equilibrium quality levels need to be associated with lower price levels.

<sup>12</sup> Note that when  $\gamma \in [0.1, 0.2]$ ,  $\theta_L$  increases initially in  $\gamma$ , due to Wal-Mart's quality improvement.

with larger discounts, especially for  $\gamma > 0.3$  (figure 6). Initially (for  $\gamma \in [0.1, 0.2]$ ), low quality purchasers do not gain much from the discount Wal-Mart gets, but as  $\gamma$  grows many new consumers (those below  $\theta = 0.5$ ) as well as some “old” high-quality consumers start enjoying the lower prices. High quality consumers, on the other hand, experience an initial decrease in surplus as the high-quality retailer enjoys a higher mark-up resulting from a pricier high-quality product; but as a larger  $\gamma$  puts pressure on the conventional retailer consumers start reaping its benefits. Importantly, consumer surplus is, with one exception ( $\gamma = 0.3$ ), always larger in scenario 2 than in scenario 1 (and, of course, always larger than in the base case).

In terms of profits, the wholesaler (manufacturer) prefers a relatively low discount rate, preferably in the (0.1, 0.4) range (see figure 7). The intuition for this result is that it is in this range where product differentiation is maximal (see figure 2) and therefore more profitable for a monopolist to engage in price discrimination. The low-quality retailer enjoys greater profits at higher discounts (as its ability to gain additional customers is enhanced) whereas the high-quality retailer prefers a low discount rate as it enjoys higher prices (figure 3) as well as larger demand (figure 5).

Comparing profits with scenario 1, a manufacturer prefers competition between quality differentiated retailers (scenario 2) as long as the discount is not too large (i.e. when it can profitably engage in price discrimination); however, it may actually prefer double marginalization (base case) if the discount rate is too large. Because price competition softens in scenario 2, retailers’ profits are larger (greater than zero) than in scenario 1 and, for  $\gamma > 0.7$ , joint retailers’ profits are greater than in the base case.

From a social planner point of view, the optimal discount rate for maximizing consumer surplus and social welfare is 1 whereas producers’ surplus is maximized at  $\gamma = 0.1$  (see figure 8).

If, on the other hand, one wants to maximize joint profits between the manufacturer and the discount retailer the optimal discount rate is about 0.3 (see figure 9).

### 3.5. Reasonable Discount Rate for Wal-Mart

In the previous section, we present how the discount rate obtained by Wal-Mart affects qualities, prices, and welfare. However, there exists an unresolved question: what is a reasonable discount rate for Wal-Mart? To our best knowledge, there is no such published information available, but we can indirectly infer a reasonable range using slotting fee information.

In an article written by the editor of *Baking Management*, Seiz (2005), one finds the following quote “*When you deal with a supermarket retailer, they negotiate with you once, then they negotiate with you about 15 times after that (...) You get your prices, and then there are slotting fees, advertising allowances, display allowances and tickets to the golf tournament.*”

On the other hand, Wal-Mart does not have any slotting fees or hidden allowances (Walton, 2005); instead it receives lower wholesale price as a compensation for shelf space (Klein and Wright, 2007). We use this differential treatment in slotting allowances to obtain a rough estimate of the plausible discount Wal-Mart can get from manufacturers.

To focus on our main point, we ignore other costs in the following analysis. A manufacturer’s profit when selling to a conventional retailer is  $\pi = wD_H - S$ , where  $S$  is the slotting allowance; conversely, the profit when selling to Wal-Mart is  $\pi = (1 - \gamma)wD_L$ , where  $\gamma wD_L$  represents the discount to Wal-Mart. A reasonable assumption is that the discount obtained by Wal-Mart is no less than  $S$ , i.e.,  $\gamma wD_L \geq S$ . Thus, if we have a measure of slotting fees, we can find a crude lower bound for Wal-Mart’s discount.

Table 3 in FTC (2003) has a ratio of slotting fee payments to (new) product revenues. In terms of our model, the ratio is computed by  $S / (pD)$ , where the subscript is omitted to simplify

notation. Though the range of slotting fee values is large, on average the slotting fee (for all retailers/divisions) is 18%, it is 16% for ice cream,<sup>13</sup> and 20% for salad dressing (products for which slotting fees are most often applied). To compare these values with Wal-Mart's discount, we can rewrite the above inequality as:

$$\frac{S}{p_L D_L} \leq \frac{\gamma w D_L}{p_L D_L} = \frac{\gamma w}{p_L}$$

That is, the left hand side is a lower bound on Wal-Mart's discount to price ratio. We compute the right hand side of this formula that corresponds to our simulation results (for  $\gamma \in [0.1, 1]$ ) reported in table 1. The second column of table 2 contains the results of this calculation. We deem discounts rate above 0.4 as unlikely as they would imply equivalent slotting fees greater than 73%, an unlikely event; similarly, a discount of 0.1 is equivalent to a slotting fee of 11.03%, which is unlikely given that slotting allowances are typically greater. Using this reasoning, assume that a reasonable range for Wal-Mart's discount is [0.2, 0.4].

Using this range, the results of scenario 2 can be better contrasted with those obtained in the base case. First, the high-quality retailer provides significantly higher quality products/services to differentiate itself in response to Wal-Mart's entry (figure 2). Second, retail prices decrease due to competition while wholesale price increases due to price discrimination (figure 3). Third, because of competition and quality improvement, joint consumer surplus and joint producer surplus are higher (figure 8).

We now turn to the comparison of scenarios 1 and 2. First, we find that quality differentiation arises in the presence of Wal-Mart. Second, wholesale price increases due to price discrimination while quality differentiation (and the resulting softening of competition) pushes retail prices increases up (except for  $p_L$  when  $\gamma = 0.4$ ). That is, Wal-Mart's lower price in the

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<sup>13</sup> Not incorporating the 443% for retailer 7 division 2.

case of replacing an existing supermarket occurs as long as the discount rate is relatively large ( $\gamma = 0.4$ ). Third, in terms of welfare, consumer surplus and producer surplus are higher except for consumer surplus when  $\gamma = 0.3$ . A closer look at the components of consumer surplus reveals that the high-quality consumers get a larger portion of the increase in consumer surplus, a result of quality improvement. Our results suggest that when the discount rate is relatively small, the increase in welfare by low-quality consumers may not be as high as usually expected or claimed.

Our overall interpretation of the model indicates that Wal-Mart's entry into a market (whether by replacing a traditional retailer -scenario 2 vs. scenario 1- or as a new entrant -scenario 2 vs. base case) is likely to positively affect total welfare (figure 8). We next turn our attention to several robustness checks of our findings.

#### **4 Robustness**

To make our model tractable we made two important assumptions (1) consumer's price sensitivity ( $x$ ) is assumed to be equal to 1 in  $y + \theta k - xp$ , and (2) the coefficient of quality improvement cost for Wal-Mart ( $c_L$ ) is equal to 1. In this section we vary  $x$  and  $c_L$  to investigate whether and how our main findings remain.

First, we assume a price sensitivity parameter of  $x = 2$ . The results for  $\gamma \in [0, 0.3]$  are presented in table 3. When consumers are more sensitive to price, we observe that a) the quality of service for the high-quality retailer is lower (although still higher than Wal-Mart's for  $\gamma \in [0.1, 0.3]$ ), b) the wholesale and retail prices are all lower (base case, scenario 1 and scenario 2), c) Wal-Mart's price falls below that observed in scenario 1 when  $\gamma = 0.3$  (as opposed to 0.4 when  $x = 1$ ); and d) the low- (high-) quality demand increases (decreases). Therefore, compared with results obtained for  $x = 1$ , low-quality consumers' welfare is higher (due to lower prices) whereas high-quality customers' welfare is smaller due to a smaller quality improvement; total

consumer surplus may be higher or smaller, but both producer surplus and total welfare are smaller.

The intuition for these results is as follows. When faced with more price sensitive consumers, the high-quality retailer incentives to improve quality erode; instead it has an added incentive to compete with the low-quality retailer via more aggressive pricing. Low-quality consumers gain at expense of the high-quality ones. The important finding is that, our main results remain (qualitatively) unchanged when we allow for more price sensitive consumers. Nevertheless, these results indicate that price sensitivity is an important factor in the model.

Next we explore the effect of different quality improvement costs for Wal-Mart ( $c_L$ ). Consistent with our assumption that  $c_L \geq c_H = 1$ , we vary  $c_L$  from 1 to 2 by 0.1 increments, and investigate its effects on the equilibrium quality levels. Because the optimal  $k_L = 1$  for all  $\gamma \in [0.2, 1]$  when  $c_L = 1$ , increases in Wal-Mart's quality improvement costs do not change Wal-Mart's quality level; i.e.,  $k_L = 1$  for all  $\gamma \in [0.2, 1]$  with all  $c_L \geq 1$ . As a consequence,  $k_L$  and  $k_H$  remain the same for all  $\gamma \in [0.2, 1]$  and  $c_L \in [1, \infty)$ . On the other hand, it is reasonable to expect some impacts of changes in  $c_L$  on equilibrium  $k_L$  and  $k_H$  for  $\gamma = 0.1$  as the optimal  $k_L$  is greater than 1 in this case.<sup>14</sup> These results are reported in table 4.

The last two columns of table 4 show when  $c_L$  changes from 1 to 2,  $k_L$  decreases from 1.0441 to 1.0249, but  $k_H$  increases slightly from 1.4674 to 1.4678. It is reasonable that Wal-Mart's response to the raise of its quality improvement cost is more sensitive than the high-quality retailer. In the case of prohibitive quality improvement cost, i.e.,  $c_L \rightarrow \infty$ , Wal-Mart chooses not to improve its quality whereas the high-quality retailer sets the quality at the highest

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<sup>14</sup> Assuming that  $c_L > 1$  in the  $\gamma = 0$  case is not relevant as the two conventional retailer case captures the essence of two identical retailers (i.e.  $c_L = c_H = 1$  is assumed when  $\gamma = 0$ ).

level 1.4683. As with our previous robustness check, results in table 4 increases our confidence in our results.

## **5 Concluding Remarks**

In this paper we develop a simple model to study wholesaler-retailer relationships that accommodate for two key features of retail markets: buyer market power and quality differentiation. Motivated by Wal-Mart's pivotal role in the retail industry, we study the effects of a large retail chain's buyer market power when it competes with conventional retailers. To make our model computationally tractable we make some heroic assumptions about the industry: upstream supply is provided by a monopolist, there is a single product, product differentiation is vertical (i.e. on the quality dimension), and there is no transformation of the product downstream. Despite this overly simplistic representation of the industry, our model does a remarkable job at predicting several observed patterns.

The occurrence of quality differentiation in our model is quite robust (i.e. for any discount rate and different assumptions). This is consistent McWilliams (2007) and Volpe and Lavoie (2008) who highlight how competitive pressure from Wal-Mart has driven traditional supermarkets to enhance the quality of the shopping experience by adding features like high-end private-label brands, deli, coffee shop, gourmet section, and gas station.

Our framework also sheds light into the much debated issue of cost savings pass-through. The usual argument used by Wal-Mart advocates is that consumers are better off because they can purchase at lower prices. We find that indeed this effect can be present, but when firms have the option of being "different" from Wal-Mart they choose to do so thereby undermining otherwise more aggressive price competition (and therefore lower equilibrium prices). This prediction is consistent with recent findings; Basker and Noel (2009) who report that Wal-Mart's

entry triggers different price responses from incumbent grocery stores: high-end grocery stores' (such as Kroger) price reductions are less than half the size of price reductions reported at low-end grocery stores. Put differently, Wal-Mart's price effect will be larger in markets where low-quality stores already exist.

In general, we find that total welfare increases with the presence of buyer market power. However, while consumers gain, most of the welfare increases are realized at the firm level. In particular, the biggest winner is the wholesaler who can profitably engage in price discrimination between the low-quality and the high-quality retailers. Further, consumers' gain is unevenly distributed, with the more high-quality concerned consumers earning a larger share of the gain.

While not explicitly modeled, our framework captures the essence of other variants. A wholesaler-retailer relationship can be more efficient in the presence of a large, sophisticated retailer. For example, Wal-Mart's size can guarantee economies of scale in shipping. Also, recent technology innovations (such as RFID<sup>15</sup>) that can be implemented in large and stable wholesaler-retailer relations can reduce inventory management costs. Theoretically, a more (or less) cost-effective supply chain relationship will be captured by our model by appropriately modifying the discount factor.

There are some caveats, however. Our comparison of price effects between scenarios 1 and 2 indicates that when Wal-Mart replaces a conventional retailer, the price decreases for large discount values ( $\gamma \geq 0.4$ ), which might be a short-run phenomenon. In the short-run, when firms cannot change the quality level, the entry of Wal-Mart would surely decrease prices. However, in the long-run, when firms are able to adjust quality, it is possible that Wal-Mart would choose to raise prices. Gregory (2009) reports that Wal-Mart is currently in the beginning stages of a

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<sup>15</sup> Radio frequency identification.

strategy remodeling effort, called “Project Impact.” The Project is aimed to build up “cleaner, less cluttered stores that will improve the shopping experience, friendlier customer service, and home in on categories where the competition can be killed.” Also, Wal-Mart’s impacts on welfare are more complex than what our model is able to capture; our approach is silent about the effects on the labor market, the local economy, traffic, pollution, etc.

Several extensions are possible. Our assumption of an exogenous discount rate can be relaxed by exploring the optimal discount rate between the wholesaler and the large retailer using a Nash bargaining approach. Alternatively, discounts can be endogenously determined by allowing the upstream market structure to be non-monopolistic (as in Snyder, 1996). Finally, in many rural areas of the U.S. there was no retailer before Wal-Mart came into town; a natural extension can study entry deterrence strategies by Wal-Mart.

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**Table 1: Simulation Results**

$\gamma$	$k_B$		$w_B$	$p_B$		$\theta_B$		$D_B$		$CS_B$		$\pi_{MB}$	$\pi_B$		$CS_B$	$PS_B$	$TW_B$
0.0000*	1.2500		0.6250	0.9375		0.7500		0.2500		0.0391		0.1563	0.0729		0.0391	0.2292	0.2682
$\gamma$	$k_L$	$k_H$	$w$	$p_L$	$p_H$	$\theta_L$	$\theta_H$	$D_L$	$D_H$	$CS_L$	$CS_H$	$\pi_M$	$\pi_L$	$\pi_H$	$CS$	$PS$	$TW$
0.0000	1.0004	1.0004	0.5002	0.5002	0.5002	0.5000	0.5000	0.2500	0.2500	0.0625	0.0625	0.2501	0.0000	0.0000	0.1251	0.2501	0.3752
0.1000	1.0441	1.4674	0.6425	0.5823	0.8241	0.5577	0.5711	0.0134	0.4289	0.0001	0.1410	0.2833	0.0001	0.0438	0.1410	0.3272	0.4682
0.2000	1.0000	1.4410	0.6781	0.5631	0.8411	0.5631	0.6304	0.0673	0.3696	0.0023	0.1233	0.2871	0.0014	0.0317	0.1256	0.3202	0.4458
0.3000	1.0000	1.3934	0.7008	0.5381	0.8162	0.5381	0.7067	0.1686	0.2933	0.0142	0.1094	0.2882	0.0080	0.0135	0.1236	0.3098	0.4334
0.4000	1.0000	1.3190	0.6566	0.4712	0.7234	0.4712	0.7906	0.3194	0.2094	0.0510	0.0958	0.2633	0.0247	0.0032	0.1468	0.2912	0.4379
0.5000	1.0000	1.2319	0.5230	0.3563	0.5556	0.3563	0.8596	0.5033	0.1404	0.1267	0.0828	0.2051	0.0477	0.0004	0.2095	0.2532	0.4627
0.6000	1.0000	1.2005	0.4070	0.2626	0.4351	0.2626	0.8601	0.5975	0.1399	0.1785	0.0953	0.1542	0.0596	0.0012	0.2738	0.2151	0.4889
0.7000	1.0000	1.2106	0.3451	0.2099	0.3828	0.2099	0.8210	0.6112	0.1790	0.1868	0.1288	0.1250	0.0650	0.0036	0.3155	0.1937	0.5092
0.8000	1.0000	1.2330	0.3024	0.1741	0.3547	0.1741	0.7753	0.6012	0.2247	0.1807	0.1662	0.1043	0.0683	0.0075	0.3469	0.1802	0.5271
0.9000	1.0000	1.2613	0.2684	0.1477	0.3387	0.1477	0.7309	0.5832	0.2691	0.1701	0.2026	0.0879	0.0705	0.0130	0.3727	0.1713	0.5440
1.0000	1.0000	1.2926	0.2386	0.1274	0.3293	0.1274	0.6901	0.5627	0.3099	0.1583	0.2365	0.0740	0.0717	0.0198	0.3948	0.1654	0.5602

Note: \* This row represents a base case (with subscript  $B$ ), where there is only a conventional retailer in the market. See below for meanings of corresponding variables.

$\gamma$ : discount rate (buyer market power measure) offered to the low-quality retailer.

$k_L$  and  $k_H$ : low- and high -quality retail quality levels, respectively.

$w$ : wholesale price.

$p_L$  and  $p_H$ : low- and high -quality retail prices, respectively.

$D_L = \theta_H - \theta_L$ : low-quality demand;  $D_H = 1 - \theta_H$ : high-quality demand.

$CS_L$  and  $CS_H$ : consumer surplus for low- and high-quality groups, respectively.

$\pi_M$ ,  $\pi_L$ , and  $\pi_H$ : profits for wholesaler, low- and high-quality retailers, respectively.

$CS = CS_L + CS_H$ : total consumer surplus.

$PS = \pi_M + \pi_L + \pi_H$ : total producer surplus.

$TW = CS + PS$ : total welfare.

**Table 2: Wal-Mart's Received Unit Discount to Price Ratio**

$\gamma$	$\frac{\gamma w}{p_L} 100\%$
0.1	11.03
0.2	24.09
0.3	39.07
0.4	55.74
0.5	73.41
0.6	93.00
0.7	115.11
0.8	138.95
0.9	163.56
1.0	187.32

*Note:* Ratios (second column) are derived using the wholesale prices ( $w$ ) and low-quality retailer prices ( $p_L$ ) reported in table 1.

**Table 3: Simulation Results for  $x = 2$**

$\gamma$	$k_B$	$w_B$	$p_B$	$\theta_B$	$D_B$	$CS_B$	$\pi_{MB}$	$\pi_B$	$CS_B$	$PS_B$	$TW_B$						
0.0000*	1.1768	0.2942	0.4413	0.7500	0.2500	0.0368	0.0735	0.0349	0.0368	0.1085	0.1453						
$\gamma$	$k_L$	$k_H$	$w$	$p_L$	$p_H$	$\theta_L$	$\theta_H$	$D_L$	$D_H$	$CS_L$	$CS_H$	$\pi_M$	$\pi_L$	$\pi_H$	$CS$	$PS$	$TW$
0.0000	1.0000	1.0000	0.2500	0.2500	0.2500	0.5000	0.5000	0.2500	0.2500	0.0625	0.0625	0.1250	0.0000	0.0000	0.1250	0.1250	0.2500
0.1000	1.0684	1.3282	0.3142	0.2887	0.3664	0.5405	0.5979	0.0573	0.4021	0.0018	0.1320	0.1426	0.0002	0.0092	0.1338	0.1520	0.2858
0.2000	1.0000	1.3037	0.3213	0.2713	0.3722	0.5425	0.6647	0.1222	0.3353	0.0075	0.1143	0.1391	0.0017	0.0077	0.1217	0.1486	0.2703
0.3000	1.0000	1.2534	0.3165	0.2488	0.3460	0.4975	0.7671	0.2696	0.2329	0.0363	0.0968	0.1334	0.0073	0.0014	0.1331	0.1422	0.2753

*Note:* See Table 1 for explanation of notation.  $x$  is consumer's price sensitivity measure.

**Table 4: Robustness of Model to Different Values of  $c_L$**

	$\gamma = 0.1$	
$c_L$	$k_L$	$k_H$
1.0	1.0441	1.4674
1.1	1.0406	1.4675
1.2	1.0376	1.4676
1.3	1.0352	1.4676
1.4	1.0331	1.4677
1.5	1.0313	1.4677
1.6	1.0297	1.4677
1.7	1.0283	1.4677
1.8	1.0270	1.4678
1.9	1.0259	1.4678
2.0	1.0249	1.4678
$\infty$	1.0000	1.4683

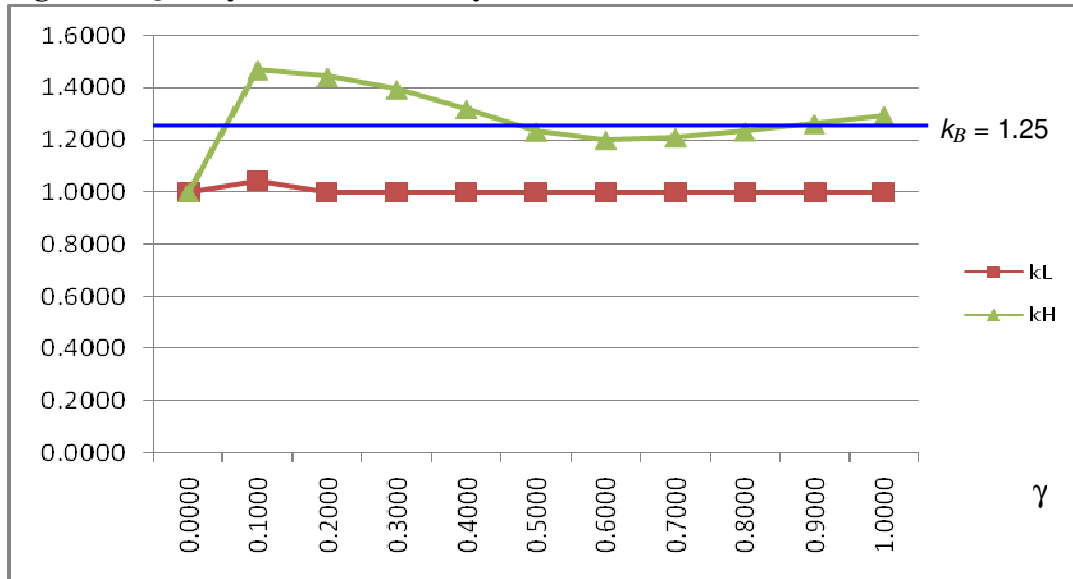
Note:  $c_L$ : coefficient of quality improvement cost for Wal-Mart.  
 $k_L$  and  $k_H$ : low- and high -quality retail quality levels, respectively.

**Figure 1: Payoff Matrix for Both Conventional Retailers When  $\gamma = 0$**

		Retailer $H$	
		$k_H = 1$	$k_H > 1$
Retailer $L$	$k_L = 1$	( 0 , 0 )	(0, 7/96)
	$k_L > 1$	(7/96, 0)	( 0 , 0 )

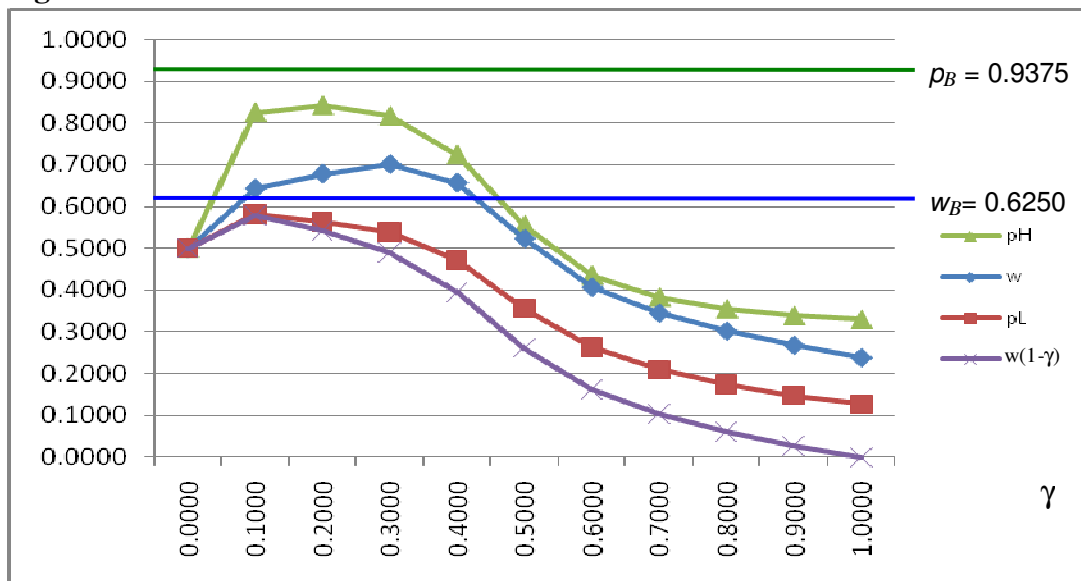
Note:  $k_L$  and  $k_H$ : low- and high -quality retail quality levels, respectively.

**Figure 2: Quality Levels Chosen by the Retailers**



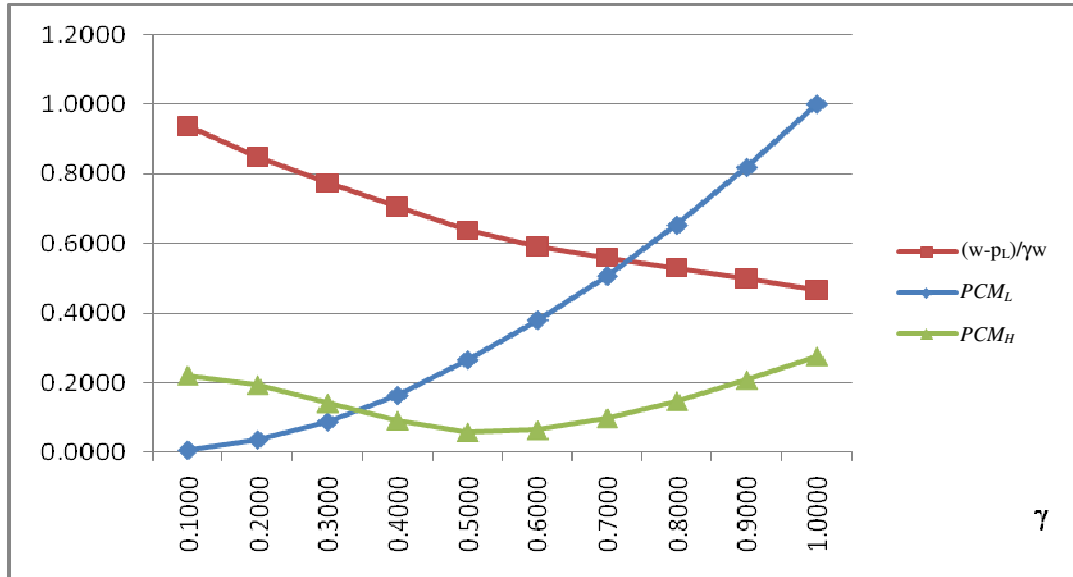
Note:  $k_L$  and  $k_H$  : low- and high -quality retail quality levels, respectively;  
 $k_B$  : base case retail quality level.

**Figure 3: Retail and Wholesale Prices**



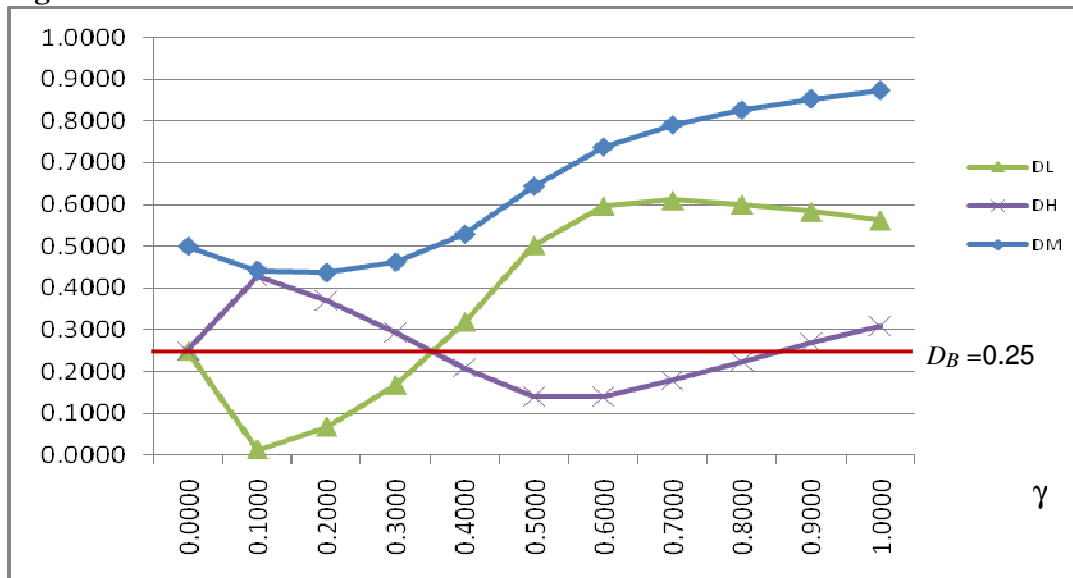
Note:  $p_H$  and  $p_L$  : high- and low-quality retail prices, respectively;  
 $w$  and  $(1-\gamma)w$  : wholesale price for high-quality retailer and discounted wholesale price for low-quality retailer, respectively;  
 $p_B$  and  $w_B$  : base case retail and wholesale prices, respectively.

**Figure 4: Retailer Price-Cost Margins and Pass-Through Rate for the Low-Quality Retailer**



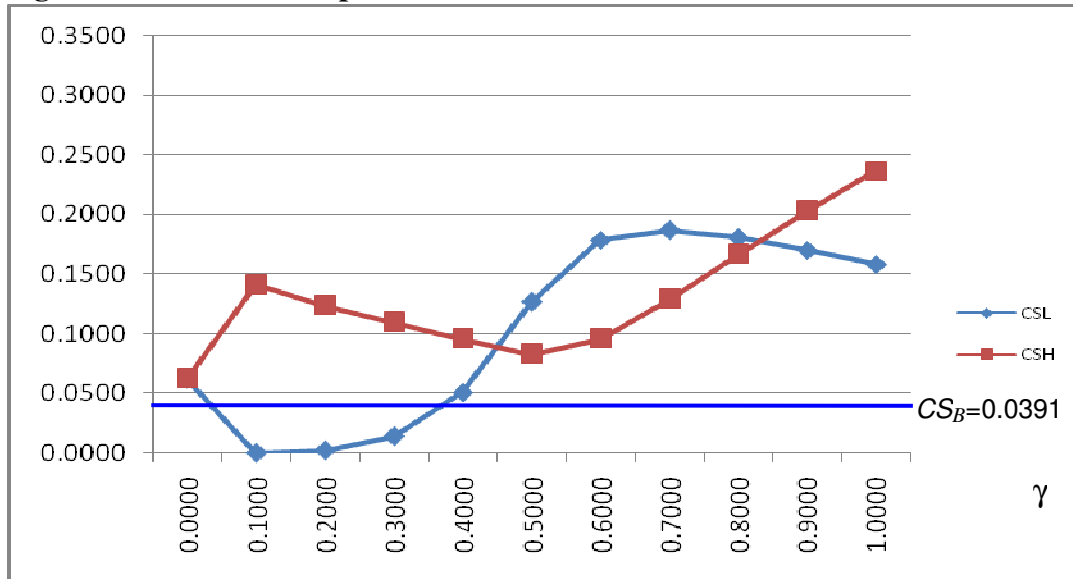
Note:  $w$  : wholesale price;  
 $p_L$ : low-quality retail price.  
 $\gamma$ : discount rate offered to the low-quality retailer.  
 $PCM_L=(p_L-(1-\gamma)w)/p_L$  : price-cost margin for the low-quality retailer.  
 $PCM_H=(p_H-w)/p_H$  : price-cost margin for the high-quality retailer.  
 $(w - p_L)/\gamma w$ : pass-through rate for the low-quality retailer.

**Figure 5: Demand**



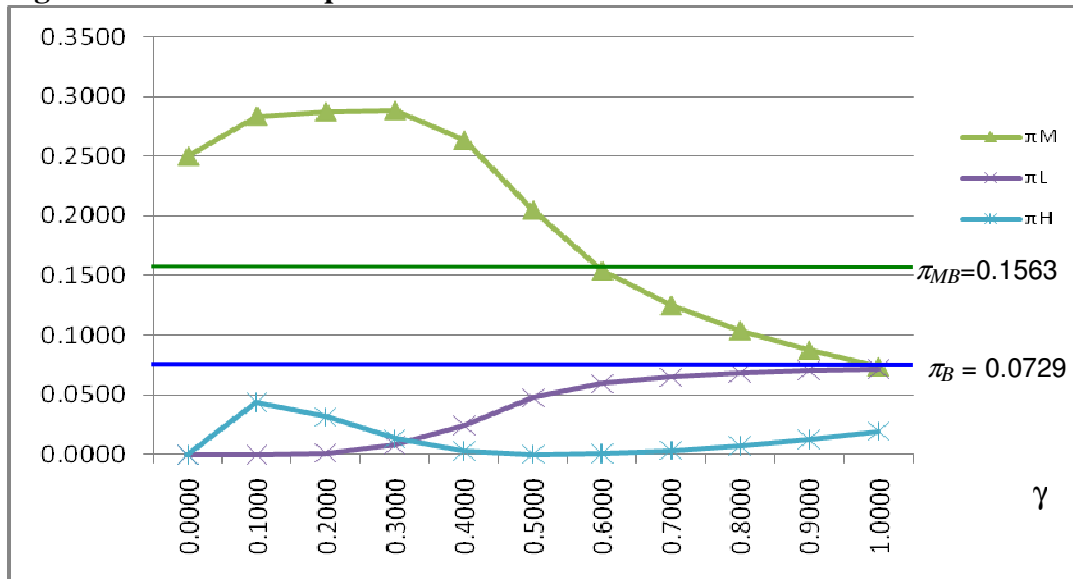
Note: High-quality demand:  $D_H = 1 - \theta_H$  ; Low-quality demand:  $D_L = \theta_H - \theta_L$  ;  
Market Demand:  $D_M = 1 - \theta_L$ ; Base case demand:  $D_B = 1 - \theta_B$ .

**Figure 6: Consumer Surplus**



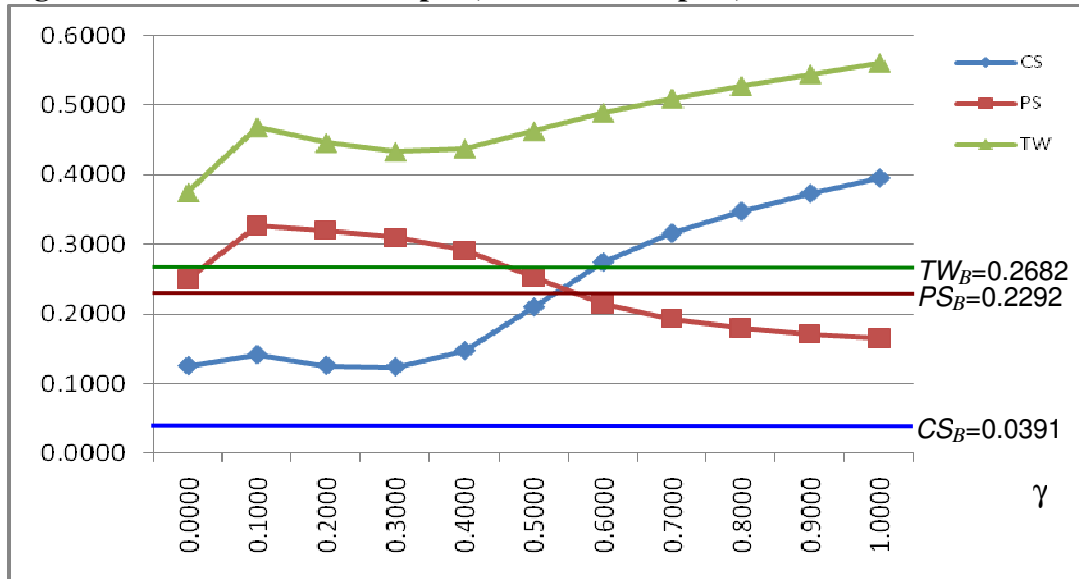
Note:  $CS_H$  and  $CS_L$ : consumer surplus for high- and low-quality groups, respectively;  
 $CS_B$ : base case consumer surplus.

**Figure 7: Producer Surplus**



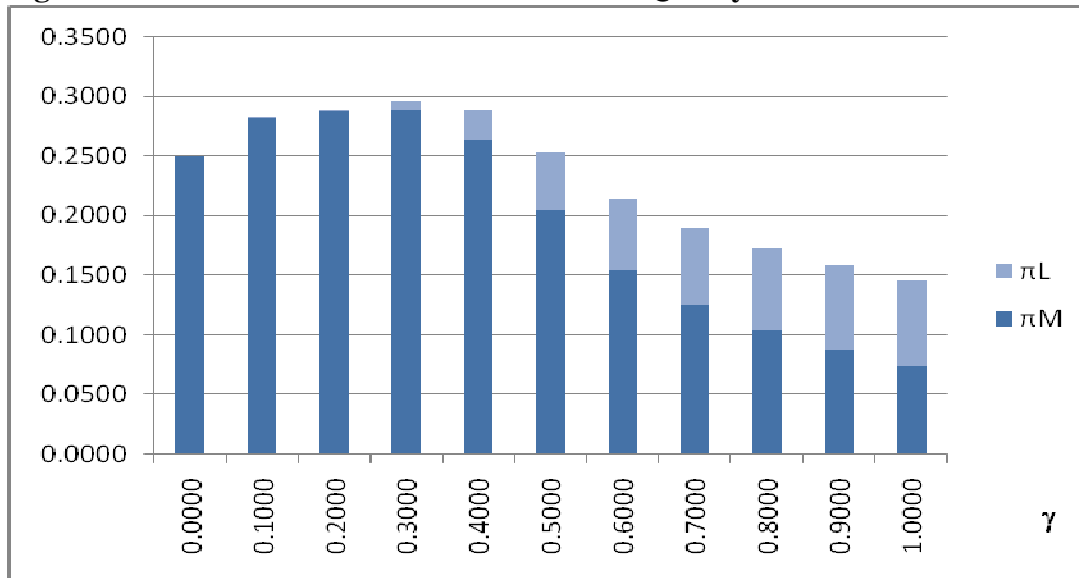
Note:  $\pi_M$ ,  $\pi_H$ , and  $\pi_L$ : profits for wholesaler, high- and low-quality retailers, respectively;  
 $\pi_{MB}$  and  $\pi_B$ : base case profits for wholesaler and retailer, respectively.

**Figure 8: Total Consumer Surplus, Producer Surplus, and Welfare**



Note: Total consumer surplus  $CS = CS_H + CS_L$ ; Total producer surplus  $PS = \pi_L + \pi_H + \pi_M$ ; Total welfare  $TW = CS + PS$ .  
 $CS_B$ ,  $PS_B$ , and  $TW_B$ : base case consumer surplus, producer surplus, and total welfare, respectively.

**Figure 9: Joint Profits of Wholesaler and Low-Quality Retailer**



Note:  $\pi_M$  and  $\pi_L$ : profits for wholesaler and low-quality retailer, respectively.