Quality Choices in a Vertical Structure: National Brands vs Private Labels in Grocery Retailing

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Abstract

The paper analyzes quality choices in a vertical structure involving a monopolist food manufacturer (national brand-NB producer) and a monopolist retailer supplying both the national brand as well as a private label (PL). The analysis is based on a three-stage dynamic game. According to the results, in the Nash equilibrium the two players choose the maximum possible qualities for their products. This means that the NB food manufacturer seeks the maximum product differentiation, while the LP retailer seeks the minimum product differentiation. The behavior of the two players appears to be consistent with actual developments in the food markets as well as with earlier empirical studies documenting the efforts of NB food manufacturers to increase product differentiation.

Key Words: *Quality Choice, National Brand, Private Label*

JEL Classification: D21, Q13

Introduction

Grocery retailing has undergone a dramatic change over the last 20 years. Concentration in the sector as well as average store size have increased. Furthermore, the bargaining position of large retailers has been improved at the expense of upstream suppliers (e.g. food manufacturers). A development which appears to have played an important role in the change of the balance of power within the food system is private label offering by large retailers. Private Labels (PLs) include all products sold under a retailer's brand name. The brand, can be created exclusively by the retailer or can be the retailer's own name. In contrast, National Brands (NBs) are those designed by and belong to food manufactures and are distributed at a national scale (Private Label Manufacturers' Association/PLMA, 2002; Berges-Sennou et al., 2004). Currently, the PLs share in the value of grocery sales has been approaching 25 percent in Western European Countries; Canada and the United States have been following with shares of 19 and 16 percent respectively (ACNielsen, 2005).

Given the growing importance of PLs in grocery retailing, in general, and in food retailing, in particular it is not accidental that the economic impact of PLs has been the focus of recent empirical and theoretical studies, excellent surveys of which can be found in Steiner (2004), and Berges-Sennu et al. (2004). The earliest theoretical studies (e.g. Raju et al., 1995; Mills, 1999; Bontems et al., 1999) have examined the impact of

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the introduction of PLs on the strategic interactions between a monopolist retailer and a monopolist NB producer. Their emphasis has been placed on changes in variables like the NBs wholesale and retail price, the NB manufacturer's and the retailer's profit, and the consumer surplus. The recent study by Collangelo (2008) has extended the framework of analysis to include retailer competition (each with its own PL) as well. Avenel and Caprice (2006) considered, in addition, optimal LP quality choices from competing downstream firms (retailers).

A common assumption in the above mentioned theoretical studies is that characteristics (the quality) of the NB good is exogenous. Therefore, the upstream manufacturer can react to quality changes in the PL, through changes in the wholesale price only. Although this may be a reasonable assumption for short-term decisions, it is certainly unrealistic for the longer-term where the manufacturer may opt to compete with the PL suppliers through further product differentiation (i.e. by changing optimally the quality of the NB good). The need for analyzing a more symmetric game between NB manufacturers and PL suppliers where the set of decisions of each agent is not *a priori* restricted has been already stressed by Berges-Sennu et al. (2004).

In this context, the objective of the present paper is to examine quality choices within a vertical structure (i.e. between a monopolist NB manufacturer and a monopolist retailer which together with the NB good sells its own PL). This is pursued through a three-stage dynamic game where quality choices of both players are endogenous. In what follows, section 2 contains the theoretical framework and section 3 the solution of the game. Section 4 presents a number of results, which are by-products of the analysis (e.g. impacts of quality changes in prices, profit shares, and consumer surplus). Section 5 offers conclusions and suggestions of future research.

Theoretical Framework

Let us assume that there is a unit mass of consumers, each of whom is interested in buying at most one unit of a food product. The utility function of consumers takes the form suggested by Mussa and Rosen (1978). That is, each consumer obtains utility

1) $$U = \theta s - p$$

if she(he) buys the food product and utility zero, otherwise. In (1) θ is a taste for quality parameter which is distributed uniformly on the interval [0, 1], s is the quality of the food product and p is the unit price. The food product comes in the market in two qualities, namely, s_H (high quality) and s_L (low quality) and at prices p_H and p_L, respectively. Then, the demand for the high quality product is given by

2) $$D_H = 1 - \frac{p_H - p_L}{s_H - s_L},$$

while the demand for the low quality product is given by

3) $$D_L = \frac{p_H - p_L}{s_H - s_L} - \frac{p_L}{s_L}$$

(Tirole, 1995); the part of the market which is not covered given qualities and prices equals p_L / s_L.

The high quality food (National Brand-NB) is produced by a monopolist manufacturer at a marginal cost of cs_H, where $0 < c < 1$ is a cost parameter, and is sold to a monopoly retailer. The low quality food (Private Label-PL) is obtained by the monopolist retailer from the competitive fringe at a price equal to the marginal cost cs_L (alternatively, it may be produced by a firm which is vertically integrated with the retailer and it sets the internal wholesale price equal to the marginal cost cs_L).

Given the above, one can envisage a three-stage dynamic game played between the manufacturer of the NB and retailer. In the first stage of the game, the two players simultaneously select the product qualities. It is assumed, here, that s_H can take any value in the interval $[s_H^*, s_H^{**}]$, s_L can take any value in the interval $[s_L^*, s_L^{**}]$, and that $s_L^{**} < s_H^{**}$ (meaning that the highest possible value of s for the low quality food will be strictly smaller than the highest possible value of s for the high quality food). This assumption is consistent with the finding of Chardon and Dumartin (1998) that consumers generally perceive PLs as being of lower quality relative to NBs and that those who buy frequently LPs consider the quality-price ratio as the main advantage of these products. Also, as noted by Berges-Sennou et al. (2004), in the food sector the production techniques are fairly standard and the R&D effort is usually low. Therefore, the major obstacle to LP food manufactures is not really to overcome technical gaps but to build reputations as high as those developed by the NB manufacturers. Note that the assumption that the quality of NBs is strictly higher that that of LPs has been employed in the recent study of Avenel and Caprice (2006). In the second stage, the NB manufacturer selects the wholesale price (w) of the NB product (given the quality decisions of the first stage). In the third stage of the game, the monopolist retailer selects the retail prices p_H and p_L (given the decisions made in the two earlier stages). Figure 1 presents the game analyzed in this paper.

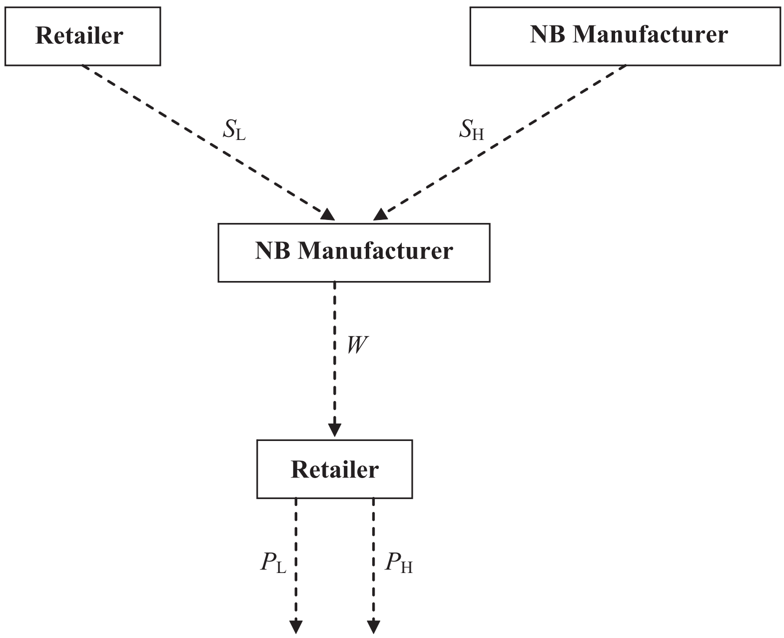

Figure 1. A Three-Stage Quality Choice Game in a Vertical Structure

The Solution of the Game

The three stage game is solved backwards. The retailer's problem in the final-stage is to maximize

3) $$\Pi^R = (p_H - w)\left(1 - \frac{p_H - p_L}{s_H - s_L}\right) + (p_L - cs_L)\left(\frac{p_H - p_L}{s_H - s_L} - \frac{p_L}{s_L}\right)$$

with respect to p_H and p_L. The first order conditions (after some simple algebra) may be written as

4.1) $$\frac{\partial \Pi^R}{\partial p_H} = 0 \Rightarrow s_H - s_L + 2p_L + w - cs_L = 0$$

4.2) $$\frac{\partial \Pi^R}{\partial p_L} = 0 \Rightarrow 2p_H s_L - ws_L - 2p_L s_H + cs_L s_H = 0.$$

The solution of the system of (4.1) and (4.2) yields[1]

5.1) $$p_H = \frac{s_H}{2} + \frac{w}{2}$$

and

5.2) $$p_L = \frac{s_L}{2}(1+c),$$

where (5.1) is the reaction function of p_H to the choice of w by the NB manufacturer.

The NB manufacturer's problem in the second stage is to select the level w maximizing

6) $$\Pi^M = (w - cs_H)\left(1 - \frac{p_H - p_L}{s_H - s_L}\right)$$

which when using p_H and p_L from (5.1) and (5.2) may be re-written as

7) $$\Pi^M = (w - cs_H)\left(\frac{1}{2} - \frac{w}{2(s_H - s_L)} + \frac{cs_L}{2(s_H - s_L)}\right).$$

The first order condition (after some simple algebra) becomes

8) $$s_H - s_L + c(s_H + s_L) - 2w = 0$$

from which follows[2]

9) $$w = \frac{s_H - s_L}{2} + \frac{c(s_H + s_L)}{2}$$

giving the reaction function of w to the quality choices.

In the first stage of the game, the NB manufacturer and the retailer make their choices simultaneously. The manufacturer selects s_H to maximize profit given s_L, the choice of w from (9) and the choice of prices from (5.1) and (5.2). With the appropriate substitutions the NB manufacturer's profit equation can be written as

10) $$\Pi^M = \left(\frac{s_H - s_L}{2} + \frac{c}{2}(s_L - s_H)\right)\left(1 - \frac{3+c}{4}\right) = \frac{s_H - s_L}{8}(1-c)^2,$$

suggesting that Π^M is increasing in s_H and decreasing in s_L. From (10), given that the manufacturer's profit is a linear function of s_H and that the coefficient of this choice variable is positive, the manufacturer maximizes profits by setting quality equal to the maximum possible value s_H^{**} (irrespective of the choice of s_L made by the retailer). The retailer selects s_L to maximize profit given s_H, the choice of *w* from (9) and the choice of prices from (5.1) and (5.2). With the appropriate substitutions the retailer's profit equation can be written as

11) $$\Pi^R = \frac{s_H + s_L}{16}(1-c)^2 + \frac{s_L}{8}(1-c)^2 = \frac{s_H + 3s_L}{16}(1-c)^2$$

suggesting that Π^R is increasing in both s_H and s_L (the marginal impact, however, of a change in s_L to Π^R is three times as that of a change in s_H). From (11), given that the retailer's profit is a linear function of s_L and the coefficient of this choice variable is positive, the retailer maximizes profits by setting quality equal to the maximum possible value s_L^{**} (irrespective of the choice of s_H made by the manufacturer). Therefore, the Nash equilibrium of the game in qualities is (s_H^{**}, s_L^{**}).

Proposition: In the dynamic game involving quality choices in a vertical structure, the monopolist NB manufacturer seeks the maximum possible product differentiation, while the monopolist retailer selling both the NB and the LP good seeks the minimum possible product differentiation.

The above result contrasts sharply with the one obtained in the dynamic model of duopoly with product differentiation (e.g. Tirole, 1995; d'Aspremont, et al., 1979) where, with the same consumer demand functions and cost functions, the two firms seek the maximum possible product differentiation (one selects the highest possible quality, while the other selects the lowest possible one). The development of the so called *me-too* products in vertical structures (that means PLs which try to resemble NBs as close as possible even in aspects like packaging) is a clear indication the PL suppliers seek to reduce product differentiation. Several empirical studies (e.g. Gabrielsen et al., 2002; Bontems et al., 2005) have found that the invasion of the PLs actually resulted in NB price increases at the retail level. Bontems et al. (2005) argue that those results can be explained by the efforts of the food NB manufactures to increase product differentiation (a counter-strategy to the LP supplier's strategy).

Certain insights may be obtained from examining the total derivatives of the *reduced form* profit functions with respect to product qualities. The *reduced form* profit function for the manufacturer is

12) $$\begin{aligned}\Pi^M(s_H) &= \Pi^M(w(s_H), p_H(s_H), p_L(s_H), s_H) = \\ &= (w(s_H) - cs_H) D_H(p_H(s_H), p_L(s_H), s_H).\end{aligned}$$

The total derivative of Π^M with respect to s_H is

13) $$\frac{d\Pi^M}{ds_H} = \frac{\partial \Pi^M}{\partial w}\frac{\partial w}{s_H} + \frac{\partial \Pi^M}{\partial p_H}\frac{\partial p_H}{\partial s_H} + \frac{\partial \Pi^M}{\partial p_L}\frac{\partial p_L}{\partial s_L} + \frac{\partial \Pi^M}{\partial s_H}.$$

The first term on the Right Hand Side is zero because of the Envelope Theorem (Chambers, 1989) and the third term is zero because of equation (5.2). One is left, therefore, with

14)
$$\frac{d\Pi^M}{ds_H}=\frac{\partial \Pi^M}{\partial p_H}\frac{\partial p_H}{\partial s_H}+\frac{\partial \Pi^M}{\partial s_H}=$$
$$=(w-cs_H)\left(\frac{\partial D_H}{\partial p_H}\frac{\partial p_H}{\partial s_H}\right)+(w-cs_H)\frac{p_H-p_L}{(s_H-s_L)^2}-c\left(1-\frac{p_H-p_L}{s_H-s_L}\right).$$

The first term on the Right Hand Side of (14) is the *indirect* (working through p_H) effect of s_H on the manufacturer's profit from the NB. The second term is the *direct* effect (for a given p_H) of s_H on the profit from the NB. The third term is the cost effect of a change in s_H. Substituting appropriately, one gets

15)
$$\frac{d\Pi^M}{ds_H}=-\frac{1-c}{4}+\frac{3+c}{8}(1-c)-c\frac{1-c}{4},$$

where the first (negative) term is the *indirect* effect, the second (positive) term is the *direct* effect, and the last (negative) term is the cost effect of a change in s_H. The total effect is $\frac{(1-c)^2}{8}>0$ suggesting that the positive *direct* profit effect dominates the other two negative effects, something which gives the economic incentive to the NB food manufacturer to choose the highest possible quality for that product.

The *reduced form* profit function for the retailer is

16)
$$\Pi^R(s_L)=\Pi^R(w(s_L),\, p_H(s_L),\, p_L(s_L),\, s_L)=$$
$$=(p_H(s_L)-w(s_L))D_H(p_H(s_L),\, p_L(s_L),\, s_L)+$$
$$+(p_L(s_L)-cs_L)D_L(p_H(s_L),\, p_L(s_L),\, s_L).$$

The total derivative of Π^R with respect to s_L is

17)
$$\frac{d\Pi^R}{ds_L}=\frac{\partial \Pi^R}{\partial w}\frac{\partial w}{\partial s_L}+\frac{\partial \Pi^R}{\partial p_H}\frac{\partial p_H}{\partial s_L}+\frac{\partial \Pi^R}{\partial p_L}\frac{\partial p_L}{\partial s_L}+\frac{\partial \Pi^M}{\partial s_L},$$

where the second and the third terms are zero because of the Envelope Theorem. One, therefore, is left with

18)
$$\frac{d\Pi^R}{ds_L}=\frac{\partial \Pi^R}{\partial w}\frac{\partial w}{\partial s_L}+\frac{\partial \Pi^M}{\partial s_L}=$$
$$=(-1)D_H\frac{c-1}{2}+(p_H-w)\frac{\partial D_H}{\partial s_L}-cD_L+(p-cs_L)\frac{\partial D_L}{\partial s_L}.$$

The first (positive) term in (18) is the *strategic* effect of the PL.[3] With the introduction of a PL the retailer reinforces its bargaining position with regard to the NB manufacturer. The reduction of the market power (expressed through the level of the wholesale price *w*) of the latter player becomes larger as the quality of the PL increases relative to that of the NB (that means, as the product differentiation becomes low). The second (negative term) is *direct* the effect of a change in s_L on the profit from the NB at the retailer level. The third (negative term) is the cost effect, while the last (positive) term is the *direct* effect of a change in s_L on the profit from the PL at the retail level. With appropriate substitutions, (18) may be re-written as

$$\text{19)} \qquad \frac{d\Pi^R}{ds_L} = \frac{(1-c)^2}{8} - \frac{(3+c)(1-c)}{16} - \frac{c(1-c)}{4} + \frac{1-c^2}{4} = \frac{3(1-c)^2}{16} > 0,$$

where the first term is the *strategic* effect, the second term is the effect on the profit from the NB, the third is the cost effect, and the fourth term is the effect on the profit from the PL. The sum of the positive effects dominates that of the negative effects and, thus, the total effect is positive.

Further Results

Besides the main theoretical result relating to quality choices, the solution of the game allows one to obtain further results concerning other interesting aspects of the problem such as market coverage, distribution of the aggregate profit between the retailer and the manufacturer, profit margins at the wholesale and the retail level, impact of quality choices on retail level prices, and consumer welfare.

a) Market Coverage:

The demand for the NB with the appropriate substitutions becomes $D_H(s_H^{**}, s_L^{**}) = \frac{1-c}{4}$. This means that less than 1/4 of the consumers opt for the NB. The demand for the PL with the appropriate substitutions becomes $D_L(s_H^{**}, s_L^{**}) = \frac{1-c}{4} = D_H(s_H^{**}, s_L^{**})$. Accordingly, the part of the market that is not covered is $\frac{p_L(s_L^{**})}{s_l^{**}} = \frac{1+c}{2}$. It is noteworthy that the demand for NB, the demand for PL, and the market coverage do not depend on the quality choices. This contrasts with the results of earlier study by Botemns et al. (1997) who, using a Mussa-Rosen utility function, found that the market share of the NB decreases with s_L. In that study, however, the quality of the NB was exogenous.

b) Distribution of Profits:

The aggregate profit is $\Pi^A(s_H^{**}, s_L^{**}) = \Pi^M(s_H^{**}, s_L^{**}) + \Pi^R(s_H^{**}, s_L^{**}) = \frac{3s_H^{**} + s_L^{**}}{16}(1-c)^2$ from which follows that the marginal impact of a change in s_H^{**} is three times as large as that of a change in s_L^{**}. The NB food manufacturer's share in the vertical structure's profit is $v_M = \frac{2(s_H^{**} - s_L^{**})}{3s_H^{**} + s_L^{**}}$. In order for the latter to be higher than 0.5 it must be the case that $s_H^{**} > 5s_L^{**}$. In every other case the retailer captures the largest share of the aggregate profit.

c) Profit Margins:

The profit margin for the NB at the retail level is

$$p_H(s_H^{**}, s_L^{**}) - w(s_H^{**}, s_L^{**}) = \frac{s_H^{**} + s_L^{**}}{4}(1-c)$$

(suggesting that it increases with both s_H and s_L). The profit margin for the LP is $p_L(s_H^{**}, s_L^{**}) - cs_L^{**} = \frac{s_L^{**}}{2}(1-c)$. The former is always higher than the latter. The profit margin of the NB at the wholesale level is $w(s_H^{**}, s_L^{**}) - cs_H^{**} = \frac{s_H^{**} - s_L^{**}}{2}(1-c)$. It is higher than the corresponding at the retail level when $s_H^{**} > 3s_L^{**}$.

d) Retail Prices:

The retail price for the NB is $p_H = s_H^{**}\frac{(3+c)}{4} + s_L^{**}\frac{(c-1)}{4}$ which is increasing in s_H^{**} and decreasing in s_L^{**}; the retail price for the PL is $p_L = s_L^{**}\frac{(1+c)}{2}$ which is increasing in s_L^{**}; the average food price (computed as weighted sum of the NB and the PL prices, weights being the market shares) is $p_{Aver} = s_H^{**}\frac{(3+c)}{4} + s_L^{**}\frac{(1+3c)}{4}\left(\frac{1-c}{4}\right)$ which is increasing in both s_H^{**} and s_L^{**}. Since $0 \le c < 1$, the impact of a change in s_H^{**} on the average price is larger that that of a change in s_L^{**}.

e) Consumer Welfare:

The consumers with $\theta \ge \frac{p_H(s_H^{**}, s_L^{**}) - p_L(s_L^{**})}{s_H^{**} - s_L^{**}} = \frac{3+c}{4}$ buy the NB and their aggregate consumer surplus is $\int_{\frac{3+c}{4}}^{1}(\theta s_H - p_H)d\theta$ which with the appropriate substitutions turns out to be equal to $\frac{(1-c)^2}{32}(s_H^{**} + 2s_L^{**})$. One observes that the surplus for the NB consumers increases with both s_H^{**} and s_L^{**}. It is noteworthy that the impact from a change in s_L^{**} is two times that of a change in s_H^{**}.

The consumers with $\frac{p_L(s_L^{**})}{s_L^{**}} \le \theta < \frac{p_H(s_H^{**}, s_L^{**}) - p_L(s_L^{**})}{s_H^{**} - s_L^{**}}$ or equivalently $\frac{1+c}{2} \le \theta < \frac{3+c}{4}$ buy the PL and their aggregate consumer surplus is $\int_{\frac{1+c}{4}}^{\frac{3+c}{4}}(\theta s_L - p_L)d\theta$

which with the appropriate substitutions turns out to be equal to $(1-c)^2 \frac{s_L^{**}}{32}$. Naturally, their welfare increases with s_L^{**}. From the total consumer surplus, $\frac{(1-c)^2}{32}(s_H^{**}+3s_L^{**})$, less than 1/3 goes to those who buy the PLs.

Conclusions

The objective of this paper has been to analyze quality choices in a vertical structure involving a monopolist manufacturer of a higher quality food product (NB) and a monopolist retailer supplying both the NB as well as a lower quality food product (PL). This has been pursued using a three-stage dynamic game, where in the first stage the players choose product qualities, in the second-stage the NB manufacturer chooses the wholesale price of the NB, and in the third stage the retailer chooses the prices for the NB and the PL. The solution of the game yielded that in the Nash equilibrium the two players choose the maximum possible qualities for their products. This means that the NB manufacturer seeks the maximum product differentiation, while the retailer seeks the minimum product differentiation. The behavior of the two players appears to be consistent with actual developments in the food markets (i.e. the existence of the *me-too*) products as well as with earlier empirical studies documenting the efforts of food NB manufacturers to increase product differentiation.

The present paper has examined the simplest possible form of a vertical structure with two monopolists. This allows focusing on quality choices but it leaves out of the picture a number of other potentially interesting aspects of the problem. Future research efforts can extend the framework of analysis by introducing competition among LP retailers and/or other pricing schemes (e.g. two-part tarrifs).

Notes

1 The second order conditions require $4(s_H - s_L) > 0$, which as shown subsequently, is satisfied in the Nash equilibrium of the game.

2 The second order condition requires $-\frac{2}{s_H - s_L} < 0$, which as shown subsequently, is satisfied in the Nash equilibrium of the game.

3 The strategic effect is also *indirect* (works through the change in *w*)

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