MANAGERIAL INCENTIVES AND PRODUCT QUALITY

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ABSTRACT

This paper examines the effect of managerial incentives in a setting where firms that supply a low-quality product compete with firms that supply a higher quality product. We find that the low-quality producing firm will be more aggressive than the high-quality producing firm in the sense that it offers a higher sales incentive to its managers. We also find that such incentives create a divergence of product quality and that both firms charge a higher price and earn a higher profit. The market share of the low-quality firm increases, while that of the (high-quality) firm decreases.

Keywords: vertical differentiation, competition, quality, managerial incentives

INTRODUCTION

The market structure of many oligopoly industries is vertically differentiated, offering products of different qualities, where consumers all agree on which product that has the higher quality. Examples of industries that fall into this setup are high-tech companies that supply computer equipment like microprocessors and graphics cards (Lauga & Ofek, 2011). The firms in such industries are large corporations with a clear separation of ownership from management. It is well known that this separation, together with oligopoly, gives rise to “Strategic Managerial Delegation” (SMD henceforth) by owners.

The literature has typically considered SMD in a homogeneous product or horizontally differentiated product oligopoly, while its implications in a vertically differentiated industry are much less studied. To the best of our knowledge, the only papers to have done so are by Ishibashi (2001), and Wang (2013). Thus, the purpose of this paper is two-fold: (i) analytically characterize the profit and sales incentive schemes for such an industry and (ii) examine its effect on market share, price, profit, and product quality of the industry.

Our findings point to the conclusions that in SMD or “incentive” equilibrium, the lower quality firm is more aggressive than the higher quality firm in the sense that it offers its managers a higher sales incentive. In comparison to standard profit maximization (SPM henceforth), we also see a greater market share of the low-quality firm. Furthermore, both firms charge higher prices and earn higher profits than under SPM. In terms of quality, our results indicate that SMD equilibrium leads to a divergence of product quality as the high-quality firm sets a higher quality than under SPM, while the quality of the low-quality firm remains unchanged.

LITERATURE SURVEY

Fershtman and Judd (1987) and Sklivas (1987) have shown that for a homogeneous good duopoly market consisting of a profit maximizing firm and a firm with a managerial incentive scheme depending on profit and sales, the latter firm may earn higher profits even when both firms face the same cost function. There is therefore an incentive to set up a non-profit maximizing objective for the manager. If both firm owners do the same, however, the profit of the owners in equilibrium will be higher (lower) than for the pure profit maximizing case under price (quantity) competition. Along with an oligopolistic market structure, the fundamental reason behind such strategic distortion rest critically on an inefficient contract. Katz (1991) showed that two other critical assumptions are needed: the contracts between the owner and manager are public information and are not negotiable within the given time frame assumed.

Ishibashi (2001) also examined managerial incentives in a vertically differentiated industry. He found that for a given quality level, a firm would prefer to reduce manager compensation if sales go up as a commitment mechanism to keep prices high. On the other hand, managers would like to increase product quality if they are offered a sales incentive. He concluded that firms might be better off if they provide a sales incentive to managers when they compete in both quality and price. Wang (2013) considered a model with managerial delegation in a vertically differentiated market, looking at the impact on optimal R&D policy and government subsidy. A detailed review of the literature on SMD is provided by Sengul, Gimeno, and Dial (2012).

MODEL

Our model is similar in spirit to Wang (2013) in that we consider a vertically differentiated duopoly industry, where the two firms – H and L - are differentiated in terms of their product quality, S_H and S_L. The owner of a firm is defined as one who decides on product quality with the objective of maximizing profits. The manager, the agent of the owner executes output, sales and pricing decisions.

Following Zhou, Spencer, and Vertinsky (2002) and Wang (2013), we assume that there are quadratic investment costs of improving quality. Specifically, firm H incurs investment costs $F(S_H) = \frac{S_H^2}{2}$, and firm L incurs $\gamma F(S_L) = \frac{\gamma S_L^2}{2}$ to develop their quality levels S_H and S_L respectively. Here, γ (>1) reflects the technology gap between the two firms, namely H and L. Because of the presence of this technology gap, the cost of producing the given quality, say S^0, is higher for firm L compared to firm H, i.e. $\gamma F(S^0{}_L) > F(S^0{}_H)$. This leads to a higher quality choice by firm H compared to firm L, namely $S_H > S_L$.

A non-cooperative three-stage game is assumed. In *stage 1*, the owners of the two firms, H and L, set up the quality level of their firm's product S_H and S_L, with the objective of maximizing their respective profits. As mentioned before, our assumptions regarding their cost functions ensure $S_H \geq S_L$ in equilibrium. In *stage 2*, given the quality levels determined in *stage 1*, the firm owners set up the structure of incentive pay to be offered to the managers. The manager of firm i is paid: $w_i + \mu_i\pi_i + \beta_i S_i$, where w_i, μ_i and β_i are constants and π_i and S_i stand respectively for profits and revenues of firm i, where $i = \{H, L\}$. The owner chooses w_i, μ_i and β_i. It is assumed that managerial services are available in a competitive market and the opportunity cost of a manager is given. Define $\alpha_i = \frac{\mu_i}{\mu_i+\beta_i}$. Then α_i and $(1 - \alpha_i)$ can be respectively interpreted as the relative profit incentive and the relative sales incentive.

These contracts are public knowledge and nonrenewable. In *stage 3*, with set quality levels S_H and S_L from *stage 1*, and pre-determined w_i, μ_i and β_i from *stage 2*, the managers of the competing firms non-cooperatively set prices. They are assumed to be risk neutral and aim to maximize $\alpha_i\pi_i + (1 - \alpha_i)S_i$. Hence, the relative profit or sales incentive, not the absolute weights, governs the performance of the firm. It is assumed that there is no uncertainty. Also, it is further assumed that the owner cannot directly verify price or quantity and therefore offers a contract indexed to profits and sales.

Following the method of backward induction, we solve the *stage 3* game first, given the quality levels S_H, S_L, and the profit incentives α_H and α_L. Here, the firms choose prices non-cooperatively in Bertrand-Nash fashion. Let the consumer's preferences be described by the equation:

$U = \theta.S_i$, if she consumes one unit of a product with quality S_i at price P,

$= 0$ if she does not consume either of the two products.

The taste parameter θ for quality is uniformly distributed across a continuous population of consumers between interval $[a,b]$ with $0 < a < 1$ and $b = a + 1$ corresponding to a density of 1. A consumer with preference parameter θ is indifferent between the two brands if and only if $\theta S_H - P_H = \theta S_L - P_L$. Consequently, the marginal consumer who is indifferent between consuming the two brands is given by $\hat{\theta} = \frac{P_H - P_L}{S_H - S_L} = \frac{P_H - P_L}{\Delta_s}$, where $\Delta_S = S_H - S_L$. We also assume that the market is covered, i.e. each consumer consumes at least one of the two brands. Thus, a consumer is better off buying the cheaper low-quality product than not buying at all, i.e. $\theta S_L - P_L \geq 0$[1]. This leads to the following demand functions D_H and D_L for firm H and firm L respectively:

$$D_H = a + 1 - \frac{P_H - P_L}{\Delta_s};\ D_L = \frac{P_H - P_L}{\Delta_s} - a; \qquad (1)$$

The stated demand functions in (1) fall in Product Quality-Dependent Demand Models, and more specifically Consumer's Utility-Based Models, in the taxonomy of demand functions established in Huang, Leng, and Parlar (2013).

Let the unit cost of producing both the high-quality product as well as the low-quality product be $\bar{c}$, a constant and same for both firms. That is, $c_H = c_L = \bar{c}$, where c_H and c_L are the unit costs of production for firm H and firm L. To guarantee that the market is covered for any quality choice of the duopolists, it is assumed that:

$$\bar{c} + \frac{2}{5}(2 - a)\Delta_S \leq aS_L \qquad (2)$$

The objective of the respective managers is as follows:

Firm H: $Max_{P^H}\ \pi_H = \frac{(P_H - \alpha_H c_H)(b - P_H - P_L)}{\Delta_S}$;

Firm L: $Max_{P^L}\ \pi_L = \frac{(P_L - \alpha_L c_L)(P_H - P_L - a)}{\Delta_S}$

We may notice that the relative profit incentives act essentially as a shift parameter of the MC function.

Also, we have ignored the cost of producing quality, because it is not determined by the managers, and hence is not included in their payoff functions. Maximizing the pay-off functions of each manager

[1] Equation (2) states formally the condition that ensures that this assumption will hold in equilibrium.

shown above, we can determine the Bertrand-Nash price solutions that maximize each manager's pay-off.

$$P_H = \frac{(2+a)\Delta_s + 2\alpha_H c_H + \alpha_L c_L}{3};\ P_L = \frac{(1-a)\Delta_s + 2\alpha_L c_L + \alpha_H c_H}{3} \qquad (3)$$

Inserting them back in the demand functions in (1), the corresponding quantities demanded are

$$D_H = b - \frac{(1+2a)\Delta_s + \alpha_H c_H - \alpha_L c_L}{3\Delta_s};\ \ D_L = \frac{(1+2a)\Delta_s + \alpha_H c_H - \alpha_L c_L}{3\Delta_s} - a \qquad (4)$$

Equations (3) -(4) give the Bertrand-Nash equilibrium prices and quantities in the *stage 3* game.

We now move on to solving the *stage 2 game* where the owners choose the respective profit and sales incentives, that is, the α_i's non-cooperatively. Maximizing $\pi_H (\alpha_H, \alpha_L)$ and $\pi_L (\alpha_H, \alpha_L)$ w.r.t. α_H and α_L respectively, the reduced form incentive solutions are:

$$\alpha_H = \frac{3(a+3)\Delta_s + 12c_H + 3c_L}{15c_H}\ ;\ \alpha_L = \frac{3(2-a)\Delta_s + 12c_L + 3c_H}{15c_L} \qquad (5)$$

Under our assumption of $c_H = c_L = \bar{c}$, we obtain

$$\alpha_H - \alpha_L = \frac{(2a+1)}{5\bar{c}}\Delta_s \qquad (6)$$

In other words, profit (sales) incentive is higher (lower) for the high-quality firm. This leads to our first proposition:

Proposition 1: *In incentive equilibrium, the lower quality firm is more aggressive in the sense that it gives a higher sales incentive.*

The intuition behind this finding is that the higher quality firm targets consumers who have a higher willingness to pay. By being more aggressive, the higher quality firm loses the chance to extract more consumer surplus from those who are willing to pay a higher price for superior quality. The reduced form solutions of prices and quantity demanded are

$$P_H = \frac{\bar{c} + 2(a+3)\Delta_s}{5};\ P_L = \frac{\bar{c} + 2(2-a)\Delta_s}{5};\ D_H = \frac{a+3}{5};\ \ D_L = \frac{2-a}{5} \qquad (7)$$

Thus, $P_H > P_L$, that is, in SMD, the higher quality firm charges a higher price. The profits of the two firms under SMD are given by:

$$\pi_H = \frac{2(a+3)^2}{25}\Delta_s;\ \pi_L = \frac{2(2-a)^2}{25}\Delta_s; \qquad (8)$$

Now we move on to the *stage 1 game*. Here, the owners choose the quality levels with the aim of maximizing profits given the technology for producing quality in their respective cost functions for producing quality. We will examine whether the managerial delegation leads to a convergence or divergence of product quality and what happens with the respective quality levels of the low and high-quality firms. The profit maximization conditions of the two firms are given by the following:

$$\text{Firm H: Maximize } \pi_H(S_H, S_L) = \frac{2(a+3)^2}{25}(S_H - S_L) - \frac{S_H^2}{2}, \text{ w.r.t. } S_H \quad (9)$$

$$\text{Firm L: Maximize } \pi_H(S_H, S_L) = \frac{2(2-a)^2}{25}(S_H - S_L) - \gamma\frac{S_L^2}{2}, \text{ w.r.t. } S_L \quad (10)$$

Differentiating (9) w.r.t. S_H we obtain the equilibrium quality choice of the high-quality firm under SMD

$$S_H^M = \frac{2(a+3)^2}{25} \quad (11)$$

Equation (10) is decreasing in S_L, so firm L will choose the lowest quality possible in the quality spectrum. This might depend on the minimum quality standard set by the government safety or quality regulations. Let us denote this quality level as $\underline{S}$.

How do the quality, price, output and profit levels under SMD compare with the case when firms do not offer managerial incentives and use standard profit maximization (SPM)? To find that out, we need to first state the corresponding level under the usual profit maximization case. Under SPM, price, output and profit is obtained by setting $\alpha_i = 1$, where $i = \{H, L\}$. Inserting $\alpha_H = \alpha_L$=1 in equations (3) and (4), we find that the values of the above-mentioned variables are given by:

$$P_H^\pi = \overline{c} + \frac{(2+a)\Delta_s}{3};\ P_L^\pi = \overline{c} + \frac{(1-a)\Delta_s}{3} \quad (12)$$

$$D_H^\pi = \frac{a+2}{3};\ D_L^\pi = \frac{1-a}{3}; \quad (13)$$

$$\pi_H^\pi = \frac{(a+2)^2}{9}\Delta_s - \frac{S_H^2}{2};\ \pi_L^\pi = \frac{(1-a)^2}{9}\Delta_s - \gamma\frac{S_L^2}{2} \quad (14)$$

Maximizing the profit function of firm H from equation (14) above w.r.t. quality S_H, we obtain the profit maximizing level of quality of firm H under SPM as $S_H^\pi = \frac{(a+2)^2}{9}$. The profit of firm L is again found to be decreasing with respect to its quality level, implying that it will choose the lowest possible quality level possible, which we had earlier denoted as $\underline{S}$. Comparing S_H^π with S_H^M above in equation (11), we find that $S_H^M > S_H^\pi$. This constitutes our second major result:

Proposition 2: *The high-quality firm produces a higher quality in incentive equilibrium than under standard profit maximization, while the low-quality firm produces the lowest possible quality allowed under government regulation in both cases. This means that there is a divergence in product quality among the firms under incentive equilibrium.*

Next, we compare the equilibrium prices, quantities and profits under SMD equilibrium and SPM equilibrium. Comparing, we can easily show that, since $0 < a < 1$, equilibrium prices and profits of both firms are higher in incentive equilibrium. While comparing the outputs sold under the two cases, however, we find that the market share of the low-quality firm increases, while that of the high-quality firm decreases under incentive equilibrium. This leads to our third and final proposition:

Proposition 3: *Both the high and low-quality firm will charge a higher price and earn a higher profit under incentive equilibrium, compared to standard profit maximization. However, the market share of the low-quality firm increases, while that of the high-quality firm decreases under incentive equilibrium.*

The intuition follows from the fact that in incentive equilibrium, the sales incentives are negative. This, while acting as an incentive for price increase and a disincentive for output increase, reduces the cut-throat nature of Bertrand competition, thus increasing prices and profits of each firm. Since the sales incentives are higher for the low-quality firm compared to the high-quality firm, however, the relative price of the low-quality firm vis-à-vis the high-quality firm, namely P_L/P_H is lower under incentive equilibrium, allowing it to capture a part of the market share from the high-quality firm.

DISCUSSION

Our results add and build upon the marketing literature and the long-standing issue of optimal salesforce compensation plans in the agency-theory realm by also demonstrating its eminence as a deliberate corporate strategic weapon in much the same way as prices, attributes, and quality are operationalized to hedge against competitors. At the micro level, our results also hold value regarding the hiring of salespeople. What we have seen is that the optimal decision on part of the low-quality firm is to provide compensation that is more heavily based on commission than fixed salary, with the reversed relationship holding for the high-quality firm. Consequently, within industry, the low-quality firm is better off hiring salespeople that are comfortable to function well under uncertainty, while the high-quality firm would not need to put as much emphasis on those qualities. Thus, one can infer that the low-quality firm would be better off hiring more risk-loving managers and salespeople than the high-quality firm.

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