PRODUCT QUALITY AND DISTRIBUTION CHANNELS*

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A B S T R A C T

We introduce strategic behaviour in assigning a certain distribution channel to a product of a particular quality. We propose a variety of models to analyze and study some of the determinants of the choice of distribution channels. Taking the Gabszewicz and Thisse's (1979) model as a benchmark, we first study whether there exist strategic incentives for delegation of sales in a vertically differentiated duopoly. Secondly, product quality is associated with a particular distribution channel. Finally, the model is extended to account for multi-quality production.

The resulting equilibria of every game depend on the relative market profitability, the degree of vertical differentiation (i.e. the relative marginal utility of income for quality and the non-buying option), and hence on the intensity of inter-quality and intra-quality competition.

In all of the games analyzed, delegation appears as an equilibrium action. In the first game it is a dominant action for both manufacturers. In the second game, at least one of the manufacturers delegates sales. Whether it is one or both crucially depends on market profitability for each quality and the intensity of inter-quality competition. In the third of the games, the single-product manufacturer delegates sales at equilibrium whereas the multi-product manufacturer delegates only one of the qualities. The multi-product manufacturer employs wholesale prices together with the decision of not delegating both qualities to optimally combine the trade-off between the intensity of intra-quality competition and intra-firm competition.

Keywords: vertical differentiation, distribution channels, multi-quality production.

JEL Classification System: D21, L29.

1 Introduction

Our goal is to introduce strategic behaviour in assigning a certain distribution channel to a product of a particular quality. Also, we wish to contribute to the study of the determinants of the choice of distribution channels. We propose a variety of models which allow us to analyze the kind of questions studied in the literature on distribution systems.

Let us consider the following example to illustrate the issues examined in this paper. The Spanish firm Basi S.A., located in Barcelona, has got the licence to produce and market the French wear brand Lacoste. Basi produces two qualities and the little crocodile label, the distinctive sign of Lacoste, is exclusively attached on the better quality clothes. Lacoste has its own franchise shops in Spain, where its high-quality clothes are sold. Basi (or Lacoste if you wish) then faces the decision of which distribution channel should it employ to sell both their qualities. It would not certainly like to market clothes with and without the crocodile tag through the same shop (for reputation reasons). In fact, Basi might even prefer to distribute just the high-quality or the low-quality wear.

The decision for consumers is not how many jumpers or pairs of trousers to buy but rather whether they should buy a jumper and, if so, whether it should be a high-quality jumper (with the crocodile tag and sold in a certain shop) or a low-quality jumper (without the tag and sold in another shop). Consumers are unanimous in ranking the quality of jumpers. An important point for a consumer is whether he can afford a high-quality jumper, i.e. not all consumers have the same income. The market described fits as well for some products in the food and beverage industries, with the growing appearance of private labels. Another relevant aspect in explaining the connection between product quality and distribution channels is the spreading of on-line services through the web, in an effort of getting hold of medium-high income consumers.

Therefore, vertical differentiation, income disparities, multiproduct quality and the strategic choice of distribution channels are elements that deserve joint analysis in order to study their interaction. The demand side takes after the well-known paper by Gabszewicz and Thisse (1979) and we will proceed in steps by extending it to account for delegation of sales and multi-quality production. We will present three multi-stage non-cooperative games played by two manufacturers to assess whether strategic behaviour may explain an association between product quality and the distribution channel selected by the manufacturers. In other words, we aim at analyzing whether product quality and distribution channels appear endogenously linked as the outcome of a non-cooperative game.

We will focus on Cournot competition in the last stage of the game. The contracts that link a manufacturer with its retailer(s) are two-part tariff contracts. There is complete information and quality levels are exogenously fixed. Under these assumptions, the resulting equilibria of every game depend on the relative market profitability, the degree of vertical differentiation (i.e. the relative marginal utility of income for quality and the non-buying option), and hence on the intensity of inter-quality and intra-quality competition.

The literature on vertical relations is quite extensive. The earlier papers by Vickers (1985) and by Bonanno and Vickers (1988) studied whether oligopolistic ¯rms had a unilateral strategic incentive to delegate sales to independent retailers for the homogeneous and di®erentiated products case, respectively.[1] An important question posed in the literature is whether retail distribution should involve the use of exclusive or common retailers, possibly along with other vertical restraints clauses. Representative papers coping with issues such as exclusive dealing, common dealership and market foreclosure include Bernheim and Whinston (1998), Besanko and Perry (1993, 1994), Gabrielsen (1996, 1997), Lin (1990) and O'Brien and Sha®er (1993, 1997). Other papers consider the mutual incentive for a manufacturer-retailer pairing to enter into exclusive trading relationships (Chang, 1992, and Dobson and Waterson, 1997). The resulting market structure when retailers are the decisive agents in choosing the distribution channels is studied by Moner-Colonques, Sempere-Monerris and Urbano (1999). Finally, it is worth mentioning a number of papers that do consider multidealer distribution systems. Recent contributions are Rey and Stiglitz (1995), Dobson and Waterson (1996) and Gabrielsen and S¿rgard (1999).

[1] An excellent survey on the value of precommitment in vertical chains is Irmen (1998).

To the best of our knowledge, vertical di®erentiation, multi-quality production and its relation with distribution channels have not yet been combined in a single model.[2] To tackle these issues, we proceed gradually. In Section 2 we set out the benchmark model, a conveniently adapted and extended version of Gabszewiz and Thisse's (1979) model. Then, we study whether there exist strategic motives for delegation of sales in a vertically di®erentiated duopoly (Section 3). The association of product quality and distribution channels is taken up in Section 4; a model that can be interpreted as the endogenous selection of quality by the decision to delegate sales. Section 5 extends the previous models to account for multi-quality production. Some concluding remarks close the paper.

We show that in all of the games analyzed, delegation appears as an equilibrium action. In the ¯rst game, it is a dominant action for both manufacturers, and contrary to the standard ¯ndings in the literature, it is not always true that a prisoners' dilemma exists. In the second game, we show that at least one of the manufacturers delegates sales. Whether one or both manufacturers delegate sales crucially depends on market pro¯tability for each quality and the intensity of inter-quality competition. In the third of the games, the single-product manufacturer delegates sales at equilibrium whereas the multi-product manufacturer delegates only one of the qualities.

[2] To be fair, there exists an extensive empirical literature on marketing devoted to study price di®erences in national and private labels, and the role played by distribution channels. Recent examples of this literature are the papers by Hoch and Banerji (1993), and Narasimham and Wilcox (1998).

Both manufacturers in the former two games and the single-product manufacturer in the third game employ wholesale prices to incentive retailers' sales. However, we have found that the multi-product manufacturer in the third game employs wholesale prices together with the decision of not delegating both qualities to optimally combine the trade-off between the intensity of intra-quality competition and intra-firm competition.

2 The benchmark model

As a benchmark model we will consider an extension of the model that was initially proposed by Gabszewicz and Thisse (1979). We assume a market with two manufacturers, manufacturer M_H produces a high-quality good whereas manufacturer M_L produces a low-quality good. Both these qualities are exogenously given. Let $T = [0;1]$ represent the set of consumers. A consumer of type $t \in T$ has an initial income given by $R(t) = R_1 + R_2 t$, with $R_1 > 0$ and $R_2 \geq 0$. All consumers have identical preferences and their utility function is defined by,

$U(0;R(t)) = u_0 R(t)$; in case of no purchase, $U(H;R(t) - p_H) = u_H(R(t) - p_H)$; if the consumer buys the high-quality product, and $U(L;R(t) - p_L) = u_L(R(t) - p_L)$; if the low-quality product is bought. The scalars $u_0; u_H$ and u_L are positive and verify $u_H > u_L > u_0 > 0$: This means that all consumers agree that the high-quality product is preferred to the low-quality product which in turn is preferred to nothing. Purchases are mutually exclusive. Then, although consumers agree on the quality ranking, each consumer has a (different) reservation price since they have different income.

The market T can be partitioned between those consumers who buy the high-quality product, those who buy the low-quality product and those who buy neither of them. Note that in Gabszewicz and Thisse's (1979) paper there are three possible demand configurations corresponding to three different cases: a) both qualities have positive demand but there are unserved consumers, b) all consumers buy either the high or the low quality product, and c) only the high quality product is sold. For the sake of the exposition, we will work with case a). Thus we will require, throughout the analysis, that the sum of the equilibrium outputs do not exceed one and that both the high and the low quality outputs be positive.

The demand expressions obtained are,

$$q_L = \frac{u_H p_H - u_L p_L}{(u_H - u_L)R_2} - \frac{u_L p_L}{(u_L - u_0)R_2}$$

$$q_H = 1 - \frac{u_H p_H - u_L p_L}{(u_H - u_L)R_2} + \frac{R_1}{R_2}$$

We wish to study quantity competition. By inverting the above demand system we obtain,

$$p_L = \frac{u_L - u_0}{u_L}(R_1 + R_2 - R_2 q_H - R_2 q_L) \qquad (1)$$

$$p_H = \frac{u_H - u_0}{u_H}(R_1 + R_2) - \left(\frac{u_H - u_0}{u_H}\right) R_2 q_H - \left(\frac{u_L - u_0}{u_H}\right) R_2 q_L \qquad (2)$$

This inverted demand system can be written in the following convenient way,

$$p_L = a_L - d_L q_H - d_L q_L \tag{3}$$

$$p_H = a_H - d_L b q_L - d_H q_H \tag{4}$$

where it is verified that $a_H > a_L$ and that $a_H > d_H; a_L > d_L$; and $d_H > d_L$. The parameter b is the relative marginal utility of income for quality, i.e. $\frac{u_L}{u_H}$. It is the case that $0 < b < 1$ and that $d_H > b d_L$.

Thus, equations (3)-(4) define a linear asymmetric (inverse) demand system incorporating vertical differentiation. Note that this piece of notation has a natural interpretation in terms of the fundamentals of the model. Thus, a_L is the reservation price of the richest consumer if he purchases the low-quality good, respectively for a_H. The parameter d_L is the difference of the reservation prices for buying the low-quality product between the richest and the poorest consumer, respectively for d_H.

In contrast with Gabszewicz and Thisse (1979), we enrich the model with assuming that the production costs are $c_H q_H$ and $c_L q_L$ for the high and low quality products, respectively. Then, $(a_H - c_H)$ denotes the unitary profitability of the high-quality product and $(a_L - c_L)$ is the unitary profitability of the low-quality product. Whenever $(a_H - c_H)$ exceeds $(a_L - c_L)$;the high-quality market can be interpreted to be "better" than the low-quality market.

Under all these assumptions, we may characterize the Cournot-Nash game played by the two manufacturers. From

$$\max_{q_H} \Pi_H = (a_H - b d_L q_L - d_H q_H - c_H) q_H$$

$$\max_{q_L} \Pi_L = (a_L - d_L q_H - d_L q_L - c_L) q_L$$

we obtain the following equilibrium quantities and payoffs,

$$q_H^* = \frac{2(a_H - c_H) - b(a_L - c_L)}{(4d_H - b d_L)} \qquad q_L^* = \frac{2d_H(a_L - c_L) - d_L(a_H - c_H)}{d_L(4d_H - b d_L)}$$

$$\Pi_H = \frac{d_H \left(2(a_H - c_H) - b(a_L - c_L)\right)^2}{(4d_H - b d_L)^2} \qquad \Pi_L = \frac{\left(2d_H(a_L - c_L) - d_L(a_H - c_H)\right)^2}{d_L(4d_H - b d_L)^2} \tag{5}$$

Positive equilibrium quantities and total output sold less than unity are ensured as long as $\frac{(a_H - c_H)}{(a_L - c_L)} < 2\frac{d_H}{d_L}$ and $\frac{(2d_H - b d_L)(a_L - c_L) + d_L(a_H - c_H)}{d_L(4d_H - b d_L)} < 1$.

The analysis proceeds in three steps. Firstly, we isolate the strategic delegation decision in a vertically differentiated duopoly. Secondly, we move to a setting where delegation of sales implies the distribution of the high-quality product whereas non-delegation implies the distribution of the low-quality product. In other words, there is an endogenous selection of quality by delegation. Finally, multiproduction is incorporated since one of the manufacturers may produce and delegate both qualities whereas the rival is only able to produce and delegate the low-quality product.

3 First model: delegation in a vertically differentiated duopoly.

Suppose there is a competitive supply of retailers. Each manufacturer can either delegate sales to a retailer or sell the product himself. The contract linking a manufacturer with a retailer is a two-part tariff. Thus, the non-cooperative game played by M_H and M_L consists of the following stages: first, the manufacturers choose simultaneously and independently whether to delegate sales (D) or not (N); then, and depending on their earlier choice, the manufacturers choose simultaneously and independently the terms of the contract; finally, there is Cournot competition. We have to solve a multi-stage game of complete and imperfect information in the spirit of the papers by Vickers (1985) and by Bonanno and Vickers (1988). We call this game G_1.

A two-part tariff contract consists of a fixed fee F_i, independent of the amount of output sold, and a per unit wholesale price w_i, a variable part that depends on total output sold, for $i = H; L$. The payoffs in (5) correspond with the case where neither manufacturer delegates sales. Denote those payoffs by Π_H^{NN} and Π_L^{NN}: Suppose now that both manufacturers opt for delegation of sales. The last stage of the game is characterized by Cournot competition between the retailers. From,

$$\max_{q_H} R_H = (a_H - bd_L q_L - d_H q_H - w_H) q_H - F_H$$

$$\max_{q_L} R_L = (a_L - d_L q_L - d_L q_H - w_L) q_L - F_L$$

By setting $\partial R_H/\partial q_H$ and $\partial R_L/\partial q_L$ equal to zero and solving for q_H and q_L we have,

$$q_H^{DD} = \frac{2(a_H - w_H) - b(a_L - w_L)}{4d_H - bd_L} \qquad q_L^{DD} = \frac{2d_H(a_L - w_L) - d_L(a_H - w_H)}{(4d_H - bd_L)d_L}$$

The manufacturers' payoffs are $\pi_H = (w_H - c_H)q_H^{DD} + F_H$; and $\pi_L = (w_L - c_L)q_L^{DD} + F_L$. Since there is a competitive supply of retailers and the manufacturer each hires just one retailer, the fixed fee F_i will be set equal to the variable profits of the retailer i. Consequently, manufacturers choose the wholesale price that maximizes their payoffs.

$$\max_{w_H} \pi_H^{DD} = (p_H - c_H)q_H^{DD}$$

$$\max_{w_L} \pi_L^{DD} = (p_L - c_L)q_L^{DD}$$

The equilibrium wholesale prices are,

$$\begin{aligned} w_H^{DD} &= c_H + \frac{bd_L\,(2bd_H(a_L - c_L) - (4d_H - bd_L)(a_H - c_H))}{(16d_H^2 - 12bd_H d_L + b^2d_L^2)} \\ w_L^{DD} &= c_L + \frac{bd_L\,(2d_L(a_H - c_H) - (4d_H - bd_L)(a_L - c_L))}{(16d_H^2 - 12bd_H d_L + b^2d_L^2)} \end{aligned}$$

It turns out that both the wholesale equilibrium prices are set below unit production costs, i.e. $w_H^{DD} < c_H$ and $w_L^{DD} < c_L$. This leads to a more competitive outcome relative to the vertically differentiated duopoly without delegation of sales. Substituting back we obtain the following equilibrium payoffs

$$\Pi_H^{DD} = \frac{2(2d_H - bd_L)((4d_H - bd_L)(a_H - c_H) - 2bd_H(a_L - c_L))^2}{(16d_H^2 - 12bd_H d_L + b^2 d_L^2)^2} \tag{6}$$

$$\Pi_L^{DD} = \frac{2d_H(2d_H - bd_L)((4d_H - bd_L)(a_L - c_L) - 2d_L(a_H - c_H))^2}{d_L(16d_H^2 - 12bd_H d_L + b^2 d_L^2)^2} \tag{7}$$

There remains to compute the payoffs when one of the manufacturers delegates sales whereas the other does not. Let the high-quality producer be the manufacturer who delegates sales. In the last stage of the game, there is Cournot competition between a retailer selling a high-quality product and a manufacturer selling a low-quality product. Thus,

$$\max_{q_H} R_H = (a_H - bd_L q_L - d_H q_H - w_H)q_H - F_H$$

$$\max_{q_L} \Pi_L^{DN} = (a_L - d_L q_L - d_L q_H - c_L)q_L$$

The equilibrium quantities are,

$$q_H^{DN} = \frac{2(a_H - w_H) - b(a_L - c_L)}{4d_H - bd_L} \qquad q_L^{DN} = \frac{2d_H(a_L - c_L) - d_L(a_H - w_H)}{(4d_H - bd_L)d_L}$$

Substituting into the high-quality manufacturer's profits we may obtain the equilibrium wholesale price $w_H^{DN} = c_H + \frac{bd_L(b(a_L - c_L) - 2(a_H - c_H))}{4(2d_H - bd_L)}$. It is the case that the manufacturer choosing delegation will set the wholesale price below the marginal cost of production in order to induce his retailer to increase sales intensity. The equilibrium payoffs are as follows,

$$\Pi_H^{DN} = \frac{(2(a_H - c_H) - b(a_L - c_L))^2}{8(2d_H - bd_L)} \tag{8}$$

$$\Pi_L^{DN} = \frac{((4d_H - bd_L)(a_L - c_L) - 2d_L(a_H - c_H))^2}{16d_L(2d_H - bd_L)^2} \tag{9}$$

It is easy to check that the payoffs in (8) correspond with those of a Stackelberg high-quality leader whereas the payoffs in (9) with those of a Stackelberg low-quality follower, for a vertically differentiated duopoly. This is a well-known result from the literature on strategic delegation: the role of delegation is to shift the reaction function in such a way that the firm that delegates becomes a leader.

[insert Table 1A and Table 1B about here]

The remaining asymmetric choice is solved in the same way. Just note that the subgames $(N; D)$ and $(D; N)$ are not symmetric. The equilibrium quantities have been grouped in Table 1A.[3] The condition for ensuring positive outputs in all cases is $\frac{a_H - c_H}{a_L - c_L} < \frac{4d_H - bd_L}{2d_L}$. Care must also be taken of the condition ensuring that total output does not exceed unity. Such condition varies in each subgame and must be compared with the one for positive outputs. As long as $0 < a_L - c_L < d_L$ the binding restriction is that $\frac{a_H - c_H}{a_L - c_L} < \frac{4d_H - bd_L}{2d_L}$. For $d_L < a_L - c_L < \frac{d_L(4d_H - bd_L)}{2d_H}$, the binding restriction is the one ensuring that $q_H^{DD} + q_L^{DD} < 1$, whereas for $\frac{d_L(4d_H - bd_L)}{2d_H} < a_L - c_L$, the binding condition is determined by $q_H^{ND} + q_L^{ND} < 1$.

[3] We offer in this section a very detailed analysis, i.e. the conditions already noted after equation (5) in the text. Though such a detailed analysis does not appear in the remainder for the sake of the exposition, these conditions have been considered throughout the paper.

We may then compute the Nash equilibrium of the game G_1 (see Table 1B). It turns out that D ("delegation") is a dominant action for each of the manufacturers. The payo®s in $(N; N)$ and $(D; D)$ are di±cult to compare and we have resorted to a numerical simulation in order to establish whether there is a prisoners' dilemma situation. Manufacturer M_H is better o® in the subgame $(D; D)$ than in subgame $(N; N)$ for large enough marginal utility of income for the high-quality product.

We know from Vickers (1985) that there is a prisoner's dilemma for the case of a homogeneous product industry. In fact, as pointed out by Irmen (1998), this result will hold as long as the variables are strategic substitutes. With strategic complementarity and horizontal product di®erentiation, Bonanno and Vickers (1988) ¯nd that delegation is both in the individual and the collective interest. What we have found is that there may not be a prisoner's dilemma with strategic substitutability and vertical di®erentiation. The above discussion can be summarized in the following proposition.

Proposition 1 The game G_1 has a unique subgame perfect equilibrium. It has the following properties: a) delegation of sales by both manufacturers is a dominant action in the ¯rst stage, and b) the equilibrium wholesale prices are set below the corresponding marginal cost of production.

Thus far, product quality is just associated with a manufacturer. Retailers add nothing to distributing the product and therefore there does not exist any relation between product quality and distribution channels. What we have shown is the existence of a unilateral incentive to delegate sales in the presence of vertical differentiation and quantity competition.

4 Second model: endogenous selection of quality by delegation.

We now extend the analysis to consider the role played by retailers when they add to the final product in the following sense: the high-quality product will be distributed. A simple way to model this situation is by assuming that each manufacturer produces just one product; it is a low-quality product if it is sold by the manufacturer himself whereas it is a high-quality product if sold through an independent retailer. In other words, we wish to study the game described in the preceding section when higher quality is associated with the use of a particular distribution channel. Call this game G_2.

Unlike game G_1, there are two identical manufacturers M_1 and M_2. In case none of the manufacturers selects delegation of sales we end up with a simple Cournot duopoly with firms producing the low-quality product. By letting $q_H = 0$ in (3) and noting that the output produced by manufacturer i is $q_{iL}; i = 1; 2$; where $q_L = q_{1L} + q_{2L}$; the equilibrium payoffs are,

$$\Pi_1^{NN} = \Pi_2^{NN} = \frac{(a_L - c_L)^2}{9d_L} \tag{10}$$

Suppose now that both manufacturers employ retailers; only the high-quality product, q_H, is sold. With obvious notation for the fixed fees (F_{1H} and F_{2H})

and the wholesale prices (w_{1H} and w_{2H}), the optimization problem in the last stage of the game is,

$$\max_{q_{1H}}(a_H - d_H(q_{1H} + q_{2H}) - w_{1H})q_{1H} - F_{1H}$$

$$\max_{q_{2H}}(a_H - d_H(q_{1H} + q_{2H}) - w_{2H})q_{2H} - F_{2H}$$

The equilibrium quantities obtained are,

$$q_{1H} = \frac{a_H - 2w_{1H} + w_{2H}}{3d_H} \qquad q_{2H} = \frac{a_H - 2w_{2H} + w_{1H}}{3d_H}$$

By proceeding in the same manner as above, the equilibrium wholesale prices are $w_{1H} = w_{2H} = \frac{6c_H - a_H}{5}$, which are lower than c_H. Substituting back we have the manufacturers' equilibrium payoffs when both of them delegate,

$$\Pi_1^{DD} = \Pi_2^{DD} = \frac{2(a_H - c_H)^2}{25d_H} \tag{11}$$

That is, what we have is a standard symmetric duopoly with delegation of sales, as in Vickers (1985). Finally, suppose that manufacturer M_1 selects delegation thus its product is sold as the high-quality product; manufacturer M_2 will not hire a retailer and its product will be sold as the low-quality product. This is a differentiated asymmetric duopoly with only one firm delegating sales. Note that these computations correspond with the $(D; N)$ asymmetric subgame in game G_1 above. Those for the $(N; D)$ subgame follow from a simple exchange of subindices. The equilibrium quantities and pay-offs for game G_2 are reported in Tables 2A and 2B.

[insert Tables 2A and 2B about here]

We make the following assumption $\frac{d_H}{d_L} > \frac{c_H}{c_L} \geq 1$; which means that the reservation price ratio between purchasing the high and the low-quality products exceeds the marginal cost of production ratio. It implies that the profitability ratio between both markets is greater than one, which seems to be the standard case with more economic content. Under this assumption the relevant bounds which ensure that all equilibrium outputs in G_2 are positive and that all aggregate outputs are smaller than one are those coming from $q_2^{DN} > 0$ and $2q_1^{DD} < 1$; respectively.

Before stating the proposition, it is worth introducing the following useful notation. First of all, t^- and t^+ are both functions of the fundamentals and correspond with the bounds ensuring positive outputs and aggregate outputs less than one, respectively; g^+ is also a function of the fundamentals and is one of the roots satisfying $\Pi_1^{DD} = \Pi_1^{ND}$(or $\Pi_2^{DD} = \Pi_2^{DN}$): Finally $R = R_1 + R_2$: See Appendix A for a more detailed description where a sketch of the proof is offered.

Proposition 2 The game G_2 has the following subgame perfect equilibria:

a) $(D; D)$ in dominant strategies under the following conditions:

a.1) either $u_0 < u_L < \frac{25u_H u_0}{17u_H + 8u_0} < u_H$:

a.2) or $u_0 < \frac{25u_H u_0}{17u_H + 8u_0} < u_L < u_H$; and $t^- < g^+ < R < t^+$:

b) and two asymmetric Nash equilibria $(N; D)$ or $(D; N)$ whenever both $u_0 < \frac{25u_H u_0}{17u_H + 8u_0} < u_L < u_H$ and $t^- < R < g^+ < t^+$:

Furthermore, the equilibrium wholesale prices are below the corresponding marginal cost of production.

Delegation, by setting $w < c$, is an action employed by manufacturers to induce a higher sales e®ort from retailers. This would be the only e®ect, a (purely) strategic one, to be considered if product quality and the choice of distribution channel were not related with each other. Here, in contrast with the game presented in the previous section, the high-quality product is exclusively sold through retailers. Consequently, the manufacturers' choice must contemplate a further feature associated with competition intensity. This e®ect is to be confronted with the one stemming from market pro¯tability, that is, from how much pro¯table is the high-quality market compared with the low-quality market. Notice that the equilibrium in dominant strategies $(D; D)$ implies a homogeneous duopoly in the high-quality product, while the asymmetric Nash equilibria suppose that a duopoly with di®erent qualities shows up. Whether one or the other appears depends most importantly on the relative size among the marginal utility of income from buying either of the qualities and also that from not buying.

When u_L is close to u_0, this means that consumers do not value much the consumption of the low-quality product and, in spite of the high degree of vertical product di®erentiation, manufacturers delegate sales for pro¯tability reasons. In other words, the pro¯ts e®ect more than compensates for the higher competition intensity under a duopoly in the high-quality market. Alternatively, when u_L is far from u_0 the degree of vertical di®erentiation is low. Provided that competition is rather intense, an additional condition is needed to ensure the above mentioned equilibrium: it is required that consumers hold enough income. Otherwise a duopoly with both qualities, and hence with di®erent distribution channels, will arise.

5 Third model: multi-quality production and distribution channels.

We now permit one of the manufacturers, say manufacturer one, to be a multiproduct ¯rm and choose the distribution pattern accordingly. In particular, it may either: a) produce and sell himself both the high and the low-quality products (action N), b) or hire a retailer for distributing the high-quality product, and sell himself the low-quality one (action H), c) or the reverse of b (action L), d) or delegate the sales of both qualities to independent and different retailers (action A). The rival manufacturer remains a single-product ¯rm producing the low-quality product and also chooses the way it will be distributed, either sold by the manufacturer itself (action N) or through a retailer (action D).

The delegation of sales of both qualities is assumed to take place through di®erent retailers (as the example in the introduction). This brings new elements into the analysis. With multi-quality production and regardless of the distribution channel, there appear three outputs in the market, namely the high-quality product o®ered by the multiproduct ¯rm, q_{HM}, the low-quality product o®ered by the same ¯rm, q_{LM}, and ¯nally the low-quality product o®ered by the rival single-product ¯rm, q_{LU}. Thus, we may identify inter-quality competition (between q_{HM} and both q_{LM} and q_{LU}), intra-quality competition (between q_{LM} and q_{LU}) and intra-firm competition (between q_{HM} and q_{LM}). Therefore, the choice of the distribution channel is a means of controlling for intra-firm competition. For example, when the multiproduct firm decides not to delegate sales at all, it directly internalizes intra-firm competition. Under delegation of both qualities through different retailers, the intensity of intra-firm competition is maximal. However, the multi-product firm may use the wholesale prices to control for it. Additionally, there is competition among manufacturers and then, depending on market profitability, inter or intra-quality competition will prevail one upon the other. The interaction of these elements will determine the equilibrium choice by manufacturers and, consequently, the distribution channel associated with a particular quality in the presence of a multi-product manufacturer.

Consider the following game, G_3. In the first stage, manufacturers choose simultaneously and independently the distribution pattern. As mentioned above, the multiproduct manufacturer chooses an action from the set $\{N; H; L; A\}$ and the single-product manufacturer chooses an action from the set $\{N; D\}$. In the second stage, manufacturers choose the terms of the two-part tariff contract, whenever appropriate. In the third stage, all the sellers face the inverse demand system: $p_L = a_L - d_L(q_{HM} + q_{LM} + q_{LU})$; $p_H = a_H - bd_L(q_{LM} + q_{LU}) - d_H q_{HM}$; and compete à la Cournot. Given the first stage manufacturers' choice we may study eight different subgames with a different number of independent sellers at the third stage of the game. For example, in the $(H;D)-$ subgame there are three independent sellers: the multi-product manufacturer selling the low-quality product and two different retailers; while in the $(N;D)-$ subgame there are only two: the multi-product manufacturer and the retailer selling the low-quality product supplied by the single-product manufacturer. The equilibrium outputs and manufacturers' payoffs for each of the subgames are presented in appendix B. Before describing the subgame perfect equilibrium of G_3, we present several partial results, which are proven in appendix C:

Lemma 1 Delegation is a dominant action for the single-product firm and it always sets the wholesale price below marginal cost.

The second partial result concerns the equilibrium wholesale prices for the multi-product manufacturer now focusing on the subgames generated when the rival manufacturer delegates sales. It is interesting to identify conditions under which the equilibrium wholesale prices are set below or above the corresponding marginal cost. Two cases are distinguished. In one of them the relative profitability ratio does not play any role, the relative position of the three marginal utilities of income is the key condition. In the second, a further condition on the size of the relative profitability ratio is required.

Proposition 3 If either i) $\frac{5}{3}u_0 < u_L$ and $u_H < \varphi^+(u_0;u_L)$ and irrespectively of the size of the relative profitability ratio,
or ii) if $\frac{5}{3}u_0 < u_L$ and $\varphi^+(u_0;u_L) < u_H$, or if $u_L < \frac{5}{3}u_0$ and $\forall u_H$; and the relative profitability ratio is big enough (i.e. $\frac{a_H - c_H}{a_L - c_L} > B \equiv \frac{4d_H^2 - 2b(1-3b)d_H d_L - 2b^3 d_L^2}{d_L(2(1+4b)d_H - b(1+3b)d_L)} >$

1), then:

a) in the HD-subgame, $w_{HM}^{HD} < c_H$.

b) in the LD-subgame, $w_{LM}^{LD} > c_L$.

c) in the AD-subgame, $w_{HM}^{AD} < c_H$ and $w_{LM}^{AD} > c_L$.

The opposite to a), b),and c) happens in part ii) when $1 < \frac{a_H - c_H}{a_L - c_L} < B$:

The result of game G_3 is the content of the following proposition,

Proposition 4 The game G_3 exhibits two equilibria. In both of them the single-product manufacturer delegates sales while the multi-product manufacturer delegates only one of the qualities. The quality delegated is a function of the profitability ratio of both markets. The high quality is delegated whenever the profitability ratio of both markets is big enough (i.e. $\frac{a_H - c_H}{a_L - c_L} > \max\{1; B\}$); the low quality is delegated otherwise. Furthermore, the wholesale prices established by manufacturers at the equilibrium path are set below the corresponding marginal costs.

Proof: See Appendix C.

To understand the meaning of a big enough profitability ratio note that part i) in Proposition 3 specifies the conditions under which $\max\{1; B\} = 1$ and therefore, the relative profitability ratio trivially satisfies that condition, the high-quality market is more profitable than the low-quality market. This happens when u_L and u_H are rather close to each other (intense inter-quality competition) and u_L is relatively far from u_0. However, in part ii) $\max\{1; B\} = B$ and therefore we need the high-quality market to be much more profitable than the low-quality market. This happens either if there is a low degree of inter-quality competition, or if consumers do not value much the purchase of the low-quality product.

Let us see the intuition behind these results. We begin by recalling the bottomline from the above games G_1 and G_2: delegation of sales will take place no matter whether product quality is associated ab initio with a particular distribution channel. Then, with a multi-product manufacturer, it seems natural to consider a game in which it has only got two first-stage actions, N and A. In that simpler model, the equilibrium obtained would entail delegation by both manufacturers, and such equilibrium would be in dominant strategies. As noted above, intra-firm competition is maximal. One wonders whether the multi-product manufacturer could do better by only delegating the sales of one of the products since, by Lemma 1, the single-product manufacturer always delegates sales.

There are several forces at play. One of them has to do with how large is the relative profitability ratio. Also, the multi-product manufacturer must consider the different types of quality competition noting that now it has two instruments at hand: firstly, the wholesale price and, secondly, the channel for each of the qualities.

Suppose we are in a heavily high-quality oriented situation, that is, the ratio $(a_H - c_H)/(a_L - c_L)$ is very large. If the multi-product manufacturer delegated the sales of both qualities, then it would use the wholesale prices to control for intra-firm competition. As stated in part c of Proposition 3, just the wholesale price of the high-quality product is set below the corresponding marginal cost of production. The opposite happens with the low-quality product but note that it would be sold at a less competitive price than the rival's. Thus, the multi-product manufacturer, by choosing to delegate only the sales of the high-quality product, achieves two things. In the first place, it induces a higher sales effort from his retailer in the high-quality market, which is very profitable. Besides, it is able to compensate for the internalization loss of intra-product market competition when it delegates both qualities to independent retailers, thus avoiding the competitive disadvantage associated with $w_{LM}^{AD} > c_L$. We may conclude that, at equilibrium, the multi-product manufacturer optimally combines the trade-off between the intensity of intra-quality competition and intra-firm competition. A parallel reasoning applies when $a_H - c_H$ is not too large relative to $a_L - c_L$ and where only the sales of the low-quality product are delegated at equilibrium. Presumably, we would have to allude to cost advantages in joint distribution to have both qualities delegated.

6 Concluding remarks

We have proposed a variety of non-cooperative multi-stage games to analyze whether product quality and distribution channels appear endogenously linked as equilibrium outcomes. The demand side of the benchmark model is that of Gabszewicz and Thisse (1979). Thus, the possible determinants in explaining the relation between product quality and distribution channels are the (exogenous) quality levels, income levels, relative market profitability, the use of di®erent channels and multi-quality production.

The theoretical analysis proceeds in steps. The ¯rst setting, a direct extension of Gabszewicz and Thisse (1979), allows us to show that delegation is the unique subgame perfect equilibrium in dominant strategies for single-product manufacturers, each one producing a vertically di®erentiated product. Then, delegation of sales is associated with the choice and distribution of the high-quality product. Delegation of sales by at least one of the manufacturers is found at equilibrium.

Finally, we have enriched the model by considering a multi-quality manufacturer ¯nding that there is a unilateral incentive to delegate sales. Furthermore, the multi-quality manufacturer never sets both equilibrium wholesale prices below the corresponding marginal costs of production. Two questions are worth analyzing: a) to widen the set of strategies available to the multi-quality manufacturer, and b) to allow retailers to introduce and market a private label. Concerning a), we have found that the multi-product manufacturer faces a trade-o® between the internalization of intra-¯rm competition and their control through wholesale prices. In fact, it never delegates the sales of both qualities. Concerning b), note that it has been documented that a national brand manufacturer does not typically market two qualities through the same retailer; a second "private label" is introduced by retailers. This is left for future research.

A Appendix: Proof of Proposition 2.

We offer a sketch of the proof. The first stage in G_2 is a symmetric game with two actions for each manufacturer. Either of them can select to delegate sales to a retailer (D) or to sell the good directly to consumers (N). Given the above mentioned symmetry four possible manufacturers' equilibrium profits appear:

$$\Pi^{DD} = \frac{2(a_H - c_H)^2}{25d_H}$$

$$\Pi^{ND} = \frac{((4d_H - bd_L)(a_L - c_L) - 2d_L(a_H - c_H))^2}{16d_L(2d_H - bd_L)^2}$$

$$\Pi^{DN} = \frac{(2(a_H - c_H) - b(a_L - c_L))^2}{8(2d_H - bd_L)}$$

$$\Pi^{NN} = \frac{(a_L - c_L)^2}{9d_L}$$

and the conditions for each possible Nash equilibrium are:

- a $(D; D)$ − Nash equilibrium will emerge whenever $\Pi^{DD} > \Pi^{ND}$;
- an $(N; N)$ − Nash equilibrium will appear if and only if $\Pi^{NN} > \Pi^{DN}$;
- and finally two, $(N; D)$ and $(D; N)$; asymmetric Nash equilibria will happen if $\Pi^{DN} > \Pi^{NN}$ and $\Pi^{ND} > \Pi^{DD}$.

For all subgames, the bound that ensures positive outputs is denoted by t^- and the bound which ensures that aggregate outputs is less than one is denoted by t^+, these bounds define the following interval for $R \equiv R_1 + R_2$:

$$t^-(\cdot) \equiv \frac{[4(u_H - u_0) - (u_L - u_0)]c_L u_L - 2(u_L - u_0)c_H u_H}{[2(u_H - u_0) - (u_L - u_0)](u_L - u_0)} < R < \frac{5}{4}R_2 + \frac{c_H u_H}{(u_H - u_0)} \equiv t^+(\cdot)$$

which in terms of the mean, m, and the standard deviation of the distribution of income, σ; can be written as:

$$\frac{[4(u_H - u_0) - (u_L - u_0)]c_L u_L - 2(u_L - u_0)c_H u_H}{[2(u_H - u_0) - (u_L - u_0)](u_L - u_0)} - \sqrt{3}\sigma < m < \frac{3\sqrt{3}}{2}\sigma + \frac{c_H u_H}{(u_H - u_0)}$$

We proceed by firstly finding the conditions under which $\Pi^{DD} > \Pi^{ND}$. The difference $\Pi^{DD} - \Pi^{ND}$ can be written as a quadratic function of R. Let us define the functions of $u_0; u_L; u_H; c_L$ and c_H; $g^-(\cdot)$ and $g^+(\cdot)$ as the two roots satisfying $\Pi^{DD} = \Pi^{ND}$. The inequality will be satisfied for $R < g^-(\cdot)$ or $R > g^+(\cdot)$, where

$$g^+(\cdot) = \frac{u_H(25(4u_H - u_L - 3u_0)u_L c_L - (u_H(114u_L - 50u_0) - 32u_L(u_L + u_0))c_H}{(2u_H - u_L - u_0)(25u_H u_0 + 7u_H u_L - 3u_L u_0)} + \frac{20(4u_H - u_L - 3u_0)((u_H - u_0)u_L c_L - (u_L - u_0)u_H c_H)\sqrt{2u_H u_L(u_H - u_0)(u_L - u_0)}}{(u_H - u_0)(u_L - u_0)(2u_H - u_L - u_0)(25u_H u_0 + 7u_H u_L - 3u_L u_0)}$$

The function $g^+(\cdot)$ is smaller than $t^-(\cdot)$ when $\frac{d_H}{d_L} > \frac{c_H}{c_L}\rho$ (where ρ is equal to $\frac{2(u_H - u_0)(u_L - u_0)(25u_H - 8u_L) + 10(4u_H - u_L - 3u_0)\sqrt{2u_H u_L(u_H - u_0)(u_L - u_0)}}{(4u_H - u_L - 3u_0)(9u_H u_L + 16u_L u_0 - 25u_H u_O) + 10(4u_H - u_L - 3u_0)\sqrt{2u_H u_L(u_H - u_0)(u_L - u_0)}}$: It turns out that ρ is negative if $u_0 < u_L < \frac{25u_H u_0}{17u_H + 8u_0} < u_H$: Since $\frac{d_H}{d_L} > \frac{c_H}{c_L}$ by assumption then $\Pi^{DD} > \Pi^{ND}$ is satisfied. When $u_0 < \frac{25u_H u_0}{17u_H + 8u_0} < u_L < u_H$ the function $g^+(\cdot)$ is greater than $t^-(\cdot)$ and $\Pi^{DD} > \Pi^{ND}$ if $R > g^+(\cdot)$:

The second step in the proof is to find the conditions under which $\Pi^{DN} > \Pi^{NN}$. Proceeding as above, we may define the functions $g^{--}(\cdot)$ and $g^{++}(\cdot)$ as the two roots satisfying $\Pi^{DN} = \Pi^{NN}$ where, $g^{++}(\cdot) = \frac{(18u_H c_H - (8u_H + 9u_L)c_L)}{(2u_H(5u_L + 4u_0) - 9u_L(u_L + u_0))} + \frac{24((u_H - u_0)u_L c_L - (u_L - u_0)u_H c_H)\sqrt{2u_H u_L(u_H - u_0)(u_L - u_0)}}{2(u_L - u_0)(2u_H - u_L - u_0)(2u_H(5u_L + 4u_0) - 9u_L(u_L + u_0))}$

Then, $\Pi^{DN} > \Pi^{NN}$ if $R < g^{--}(\cdot)$ or $R > g^{++}(\cdot)$: However, it is easy to show that $g^{++}(\cdot)$ is always smaller than $t^-(\cdot)$ and therefore $\Pi^{DN} > \Pi^{NN}$: Then the results of the proposition follow.

B Appendix: G_3 Subgame Equilibrium Outcomes.

The manufacturers' first stage action choice gives rise to eight different subgames. This appendix displays the equilibrium outputs, wholesale prices (when appropriate) and the manufacturers' payoffs for each of them. The notation is:

q_v^z or w_v^z denotes the equilibrium output or wholesale price, respectively, of good v in the $z-$ subgame, where $v \in V = \{HM; LM; LU\}$ and $z \in Z = \{N; H; L; A\} \times \{N; D\}$.

Π_i^z denotes the equilibrium payoff to manufacturer i in the $z-$ subgame, where $i \in I = \{M; U\}$:

NN-subgame:

$$q_{HM}^{NN} = \frac{3(a_H - c_H) - (1+2b)(a_L - c_L)}{6d_H - (1+4b+b^2)d_L};\; q_{LM}^{NN} = \frac{(2d_H + b^2 d_L)(a_L - c_L) - (1+2b)d_L(a_H - c_H)}{d_L(6d_H - (1+4b+b^2)d_L)};$$

$$q_{LU}^{NN} = \frac{(2d_H - b(1+b)d_L)(a_L - c_L) - (1-b)d_L(a_H - c_H)}{d_L(6d_H - (1+4b+b^2)d_L)}$$

$$w_{HM}^{NN} = w_{LM}^{NN} = w_{LU}^{NN} = \;;$$

$$\pi_M^{NN} = \frac{d_L(9d_H - (2+5b+2b^2)d_L)(a_H - c_H)^2 - d_L(2(2+7b)d_H - (1+5b+9b^2+3b^3)d_L)(a_H - c_H)(a_L - c_L) + (4d_H^2 - (1+2b-4b^2)d_H d_L - b^2(1+3b+b^2)d_L^2)(a_L - c_L)^2}{d_L(6d_H - (1+4b+b^2)d_L)^2}$$

$$\pi_U^{NN} = d_L(q_{LU}^{NN})^2$$

HN-subgame:

$$q_{HM}^{HN} = \frac{9(a_H - c_H) - 2(1+3b)(a_L - c_L)}{2(9d_H - (1+6b)d_L)};\; q_{LM}^{HN} = q_{LU}^{HN} = \frac{2(3d_H - bd_L)(a_L - c_L) - 3d_L(a_H - c_H)}{2d_L(9d_H - (1+6b)d_L)}$$

$$(w_{HM}^{HN} - c_H) = \frac{2(d_H + b^2 d_L)(a_L - c_L) - (1+3b)d_L(a_H - c_H)}{9d_H - (1+6b)d_L};\; w_{LM}^{HN} = w_{LU}^{HN} = \;;$$

$$\pi_M^{HN} = \frac{9d_L(a_H - c_H)^2 - 4(1+3b)d_L(a_H - c_H)(a_L - c_L) + 4(d_H + b^2 d_L)(a_L - c_L)^2}{4d_L(9d_H - (1+6b)d_L)}$$

$$\pi_U^{HN} = d_L(q_{LU}^{HN})^2$$

LN-subgame:

$$q_{HM}^{LN} = \frac{(8d_H - 3bd_L)(a_H - c_H) - 2b(3d_H - bd_L)(a_L - c_L)}{2\left(8d_H^2 - b(6+b)d_H d_L + b^2 d_L^2\right)};\; q_{LM}^{LN} = \frac{2d_H(4d_H - (1-b)bd_L)(a_L - c_L) - d_L(4(1+b)d_H + bd_L)(a_H - c_H)}{2d_L\left(8d_H^2 - b(6+b)d_H d_L + b^2 d_L^2\right)};$$

$$q_{LU}^{LN} = \frac{2d_H(2d_H - b(1+b)d_L)(a_L - c_L) - d_L(2(1-b)d_H + bd_L)(a_H - c_H)}{2d_L\left(8d_H^2 - b(6+b)d_H d_L + b^2 d_L^2\right)}$$

$$(w_{LM}^{LN} - c_L) = \frac{d_H((1+3b)d_L(a_H - c_H) - 2(d_H + b^2 d_L)(a_L - c_L))}{8d_H^2 - b(6+b)d_H d_L + b^2 d_L^2};\; w_{HM}^{LN} = w_{LU}^{LN} = \;;$$

$$\pi_M^{LN} = \frac{d_L(8d_H + d_L)(a_H - c_H)^2 - 4(1+3b)d_H d_L(a_H - c_H)(a_L - c_L) + 4d_H(d_H + b^2 d_L)(a_L - c_L)^2}{4d_L\left(8d_H^2 - b(6+b)d_H d_L + b^2 d_L^2\right)}$$

$$\pi_U^{LN} = d_L(q_{LU}^{LN})^2$$

AN-subgame:

$$q^{AN}_{HM} = \frac{4(a_H - c_H) - (1+3b)(a_L - c_L)}{8d_H - (1+6b+b^2)d_L}; \quad q^{AN}_{LM} = \frac{(4d_H - (1-b)bd_L)(a_L - c_L) - 2(1+b)d_L(a_H - c_H)}{d_L(8d_H - (1+6b+b^2)d_L)};$$

$$q^{AN}_{LU} = \frac{(2d_H - b(1+b)d_L)(a_L - c_L) - (1-b)d_L(a_H - c_H)}{d_L(8d_H - (1+6b+b^2)d_L)}$$

$$(w^{AN}_{HM} - c_H) = -(w^{AN}_{LM} - c_L) = \frac{2(d_H + b^2 d_L)(a_L - c_L) - (1+3b)d_L(a_H - c_H)}{8d_H - (1+6b+b^2)d_L}; \quad w^{AN}_{LU} = \emptyset$$

$$\pi^{AN}_{M} = \frac{d_L(9d_H - (2+5b+2b^2)d_L)(a_H - c_H)^2 - d_L(2(2+7b)d_H - (1+5b+9b^2+3b^3)d_L)(a_H - c_H)(a_L - c_L) + (4d_H^2 - (1+2b-4b^2)d_H d_L - b^2(1+3b+b^2)d_L^2)(a_L - c_L)^2}{d_L(8d_H - (1+6b+b^2)d_L)}$$

$$\pi^{AN}_{U} = d_L(q^{AN}_{LU})^2$$

ND-subgame:

$$q^{ND}_{HM} = \frac{(8d_H - (1+6b+b^2)d_L)(a_H - c_H) - (2(1+3b)d_H - b(3+4b+b^2)d_L)(a_L - c_L)}{4(d_H - bd_L)(4d_H - (1+b)^2 d_L)}; \quad q^{ND}_{LM} = \frac{(4d_H^2 - 4(1-b)bd_H d_L - b^2(1+b)^2 d_L^2)(a_L - c_L) - d_L(2(1+3b)d_H - b(3+4b+b^2)d_L)(a_H - c_H)}{4d_L(d_H - bd_L)(4d_H - (1+b)^2 d_L)};$$

$$q^{ND}_{LU} = \frac{(2d_H - b(1+b)d_L)(a_L - c_L) - (1-b)d_L(a_H - c_H)}{4d_L(d_H - bd_L)}$$

$$(w^{ND}_{LU} - c_L) = \frac{(2d_H - (1+b^2)d_L)[(1-b)d_L(a_H - c_H) - (2d_H - b(1+b)d_L)(a_L - c_L)]}{(d_H - bd_L)(4d_H - (1+b)^2 d_L)}$$

$$w^{ND}_{HM} = w^{ND}_{LM} = \emptyset$$

$$\pi^{ND}_{M} = \frac{d_L(16d_H - (3+10b+3b^2)d_L)(a_H - c_H)^2 - 2d_L(2(1+7b)d_H - b(5+8b+3b^2)d_L)(a_H - c_H)(a_L - c_L) + (4d_H^2 - 4b(1-3b)d_H d_L - 3b^2(1+b)^2 d_L^2)(a_L - c_L)^2}{16d_L(d_H - bd_L)(4d_H - (1+b)^2 d_L)}$$

$$\pi^{ND}_{U} = \frac{2d_L(d_H - bd_L)}{(4d_H - (1+b)^2 d_L)}(q^{ND}_{LU})^2$$

HD-subgame:

$$q^{HD}_{HM} = \frac{3(8d_H - 3bd_L)(a_H - c_H) - 2((2+9b)d_H - b(1+3b)d_L)(a_L - c_L)}{2\left(24d_H^2 - 2(1+13b)d_H d_L + b(1+6b)d_L^2\right)}; \quad q^{HD}_{LM} = \frac{(2d_H - bd_L)[2(3d_H - 2bd_L)(a_L - c_L) - 3d_L(a_H - c_H)]}{2d_L\left(24d_H^2 - 2(1+13b)d_H d_L + b(1+6b)d_L^2\right)};$$

$$q^{HD}_{LU} = \frac{(4d_H - bd_L)[2(3d_H - bd_L)(a_L - c_L) - 3d_L(a_H - c_H)]}{2d_L\left(24d_H^2 - 2(1+13b)d_H d_L + b(1+6b)d_L^2\right)}$$

$$(w^{HD}_{HM} - c_H) = \frac{2(2d_H^2 - b(1-3b)d_H d_L - b^3 d_L^2)(a_L - c_L) - d_L(2(1+4b)d_H - b(1+3b)d_L)(a_H - c_H)}{\left(24d_H^2 - 2(1+13b)d_H d_L + b(1+6b)d_L^2\right)}$$

$$(w^{HD}_{LU} - c_L) = \frac{d_H[3d_L(a_H - c_H) - 2(3d_H - bd_L)(a_L - c_L)]}{\left(24d_H^2 - 2(1+13b)d_H d_L + b(1+6b)d_L^2\right)}; \quad w^{HD}_{LM} = \emptyset$$

$$\pi^{HD}_{M} = d_L(q^{HD}_{LM})^2 + \frac{[(24d_H^2 - (4+25b)d_H d_L + 2b(1+3b)d_L^2)(a_H - c_H) - 2b(9d_H^2 + (1-9b)d_H d_L + 2b^2 d_L^2)(a_L - c_L)]}{2\left(24d_H^2 - 2(1+13b)d_H d_L + b(1+6b)d_L^2\right)} q^{HD}_{HM}$$

$$\pi^{HD}_{U} = \frac{d_L(2d_H - bd_L)}{(4d_H - bd_L)}(q^{HD}_{LU})^2$$

LD-subgame:

$$q_{HM}^{LD} = \frac{(10d_H - 3bd_L)(a_H - c_H) - 2b(4d_H - bd_L)(a_L - c_L)}{2\left(10d_H^2 - b(7+b)d_H d_L + b^2 d_L^2\right)};\; q_{LM}^{LD} = \frac{2d_H\left(8d_H^2 - 2b(3-2b)d_H d_L + (1-b)b^2 d_L^2\right)(a_L - c_L) - d_L\left(4(2+3b)d_H^2 - 2b(3+2b)d_H d_L + b^2 d_L^2\right)(a_H - c_H)}{2d_L(2d_H - bd_L)\left(10d_H^2 - b(7+b)d_H d_L + b^2 d_L^2\right)};$$

$$q_{LU}^{LD} = \frac{(4d_H - bd_L)[2d_H(2d_H - b(1+b)d_L)(a_L - c_L) - d_L(2(1-b)d_H - bd_L)(a_H - c_H)]}{2d_L(2d_H - bd_L)\left(10d_H^2 - b(7+b)d_H d_L + b^2 d_L^2\right)}$$

$$(w_{LM}^{LD} - c_L) = \frac{d_H[d_L(2(1+4b)d_H - b(1+3b)d_L)(a_H - c_H) - 2(2d_H^2 - b(1-3b)d_H d_L - b^3 d_L^2)(a_L - c_L)]}{(2d_H - bd_L)\left(10d_H^2 - b(7+b)d_H d_L + b^2 d_L^2\right)}$$

$$(w_{LU}^{LD} - c_L) = \frac{d_L(2(1-b)d_H - bd_L)(a_H - c_H) - 2d_H(2d_H - b(1+b)d_L)(a_L - c_L)]}{(2d_H - bd_L)\left(10d_H^2 - b(7+b)d_H d_L + b^2 d_L^2\right)};\; w_{HM}^{HD} = ;$$

$$\Pi_M^{LD} = d_H(q_{HM}^{LD})^2 + \frac{[2d_H(2d_H - b(1+b)d_L)(a_L - c_L) - d_L(2(1-b)d_H - bd_L)(a_H - c_H)]}{2d_L\left(10d_H^2 - b(7+b)d_H d_L + b^2 d_L^2\right)} q_{LM}^{LD}$$

$$\Pi_U^{LD} = \frac{d_L(2d_H - bd_L)}{(4d_H - bd_L)}(q_{LU}^{LD})^2$$

AD-subgame:

$$q_{HM}^{AD} = \frac{2(5d_H - 2bd_L)(a_H - c_H) - (2(1+4b)d_H - b(1+3b)d_L)(a_L - c_L)}{\left(20d_H^2 - 2(1+12b+b^2)d_H d_L + b(1+6b+b^2)d_L^2\right)};\; q_{LM}^{AD} = \frac{\left(8d_H^2 - 2b(3-2b)d_H d_L + (1-b)b^2 d_L^2\right)(a_L - c_L) - 2d_L((2+3b)d_H - b(1+b)d_L)(a_H - c_H)}{d_L\left(20d_H^2 - 2(1+12b+b^2)d_H d_L + b(1+6b+b^2)d_L^2\right)};$$

$$q_{LU}^{AD} = \frac{(4d_H - bd_L)[(2d_H - b(1+b)d_L)(a_L - c_L) - (1-b)d_L)(a_H - c_H)]}{d_L\left(20d_H^2 - 2(1+12b+b^2)d_H d_L + b(1+6b+b^2)d_L^2\right)}$$

$$(w_{LM}^{AD} - c_L) = -(w_{HM}^{AD} - c_H) = \frac{d_L(2(1+4b)d_H - b(1+3b)d_L)(a_H - c_H) - 2(2d_H^2 - b(1-3b)d_H d_L - b^3 d_L^2)(a_L - c_L)]}{\left(20d_H^2 - 2(1+12b+b^2)d_H d_L + b(1+6b+b^2)d_L^2\right)}$$

$$(w_{LU}^{AD} - c_L) = \frac{2d_H[(1-b)d_L(a_H - c_H) - (2d_H - b(1+b)d_L)(a_L - c_L)]}{\left(20d_H^2 - 2(1+12b+b^2)d_H d_L + b(1+6b+b^2)d_L^2\right)}$$

$$\Pi_M^{AD} = \frac{(2d_H - bd_L)[(2d_H - b(1+b)d_L)(a_L - c_L) - (1-b)d_L)(a_H - c_H)]}{\left(20d_H^2 - 2(1+12b+b^2)d_H d_L + b(1+6b+b^2)d_L^2\right)} q_{LM}^{AD} + \frac{[(10d_H^2 - 2(1+6b)d_H d_L + b(1+3b)d_L^2)(a_H - c_H) - ((-2+8b)d_H^2 + b(1-9b)d_H d_L + 2b^3 d_L^2)(a_L - c_L)]}{\left(20d_H^2 - 2(1+12b+b^2)d_H d_L + b(1+6b+b^2)d_L^2\right)} q_{LM}^{LD}$$

$$\Pi_U^{AD} = \frac{d_L(2d_H - bd_L)}{(4d_H - bd_L)}(q_{LU}^{AD})^2$$

C Appendix: Proofs of Lemma 1 and Propositions 3 and 4.

Most of the calculations of this proof are not included here for obvious reasons. However they can be gotten from the authors upon request.

We firstly prove Lemma 1.

First, notice that $\Pi_U^{ND} > \Pi_U^{NN}$ if $(2d_H - (1 + b^2)d_L)^2 > 0$.

The remaining cases are proven by computing the difference in profits between delegation and non-delegation of sales and assessing the sign of the resulting polynomial which is a function of $\frac{d_H}{d_L} = \frac{(u_H - u_0)u_L}{(u_L - u_0)u_H}$ and $b = \frac{u_L}{u_H}$. Notice that for a given pair $(u_0; u_H)$ the former function is decreasing in u_L, ranging from $+\infty$ to 1; and the latter is increasing with u_L ranging from $\frac{u_0}{u_H}$ to 1.

Next, $\Pi_U^{LD} > \Pi_U^{LN}$ iff $f_L((\frac{d_H}{d_L}); b) = 56(\frac{d_H}{d_L})^3 - 4b(17 + 6b)(\frac{d_H}{d_L})^2 + 2b^2(13 + b(8 + b))(\frac{d_H}{d_L}) - b^3(3 + 2b) > 0$. This function is an increasing and convex function of $(\frac{d_H}{d_L})$; then $f_L((\frac{d_H}{d_L}); b) > f_L(1; b) = 56 - 68b + 2b^2 + 13b^3$; besides $f_L(1; b)$ is decreasing with b and therefore if $f_L(1; 1) > 0$ then $f_L((\frac{d_H}{d_L}); b) > 0$, which is the case. We conclude that $\Pi_U^{LD} > \Pi_U^{LN}$.

Similarly $\Pi_U^{HD} > \Pi_U^{HN}$ iff $f_H((\frac{d_H}{d_L}); b) = 72(\frac{d_H}{d_L})^3 - 6(8 + 17b)(\frac{d_H}{d_L})^2 + (4 + b(52 + 5b))(\frac{d_H}{d_L}) - 2b(1 + b)(1 + 6b) > 0$.

This function is increasing with $(\frac{d_H}{d_L})$ if either $(\frac{d_H}{d_L}) > \frac{8+17b+\sqrt{40-40b-29b^2}}{36}$ or $(\frac{d_H}{d_L}) < \frac{8+17b-\sqrt{40-40b-29b^2}}{36}$, but it can be easily proven that either $\frac{8+17b+\sqrt{40-40b-29b^2}}{36} < 1 < (\frac{d_H}{d_L})$ or the discriminant is negative. Therefore it is true that $f_H((\frac{d_H}{d_L}); b) > f_H(1; b) = 28 - 52b + 39b^2 - 12b^3$. $f_H(1; b)$ is a decreasing function of b and therefore if $f_H(1,1) > 0$ then $f_H((\frac{d_H}{d_L}),b) > 0$, which is the case. Hence, we conclude that $\Pi_U^{HD} > \Pi_U^{HN}$.

Finally, $\Pi_U^{AD} > \Pi_U^{AN}$ iff

$f_A((\frac{d_H}{d_L}),b) = 56(\frac{d_H}{d_L})^3 - 24(1+4b+b^2)(\frac{d_H}{d_L})^2 + 2(1+14b+30b^2+14b^3+b^4)(\frac{d_H}{d_L}) - b(1+b)^2(1+6b+b^2) > 0.$

Some cumbersome algebra and numerical computations show that $f_A((\frac{d_H}{d_L}),b) > 0$. Whenever we refer to numerical computations it is meant that a three-dimensional plot of the corresponding function has been run using Mathematica 4.0 and shows that the function is always above or below zero. This ends the proof of lemma 1.

Simple algebraic manipulations of the corresponding expressions appearing in Appendix B yield the value of $B \equiv \frac{4d_H^2 - 2b(1-3b)d_H d_L - 2b^3 d_L^2}{d_L(2(1+4b)d_H - b(1+3b)d_L)}$ which is the bound on the profitability ratio of both markets that determines, in Proposition 3, whether wholesale prices are greater or lower than the corresponding marginal costs. We have to establish under which conditions B exceeds one. This happens iff $u_H(2u_H(u_L+u_0) - 7u_L^2 + 4u_L u_0 - u_0^2) + 2u_L(u_L - u_0)(u_L + 2u_0) > 0$, that is if either $u_H < \varphi^-$ or $u_H > \varphi^+$, where $\varphi^+ = \frac{7u_L^2 - 4u_L u_0 + u_0^2 + \sqrt{33u_L^4 - 88u_L^3 u_0 + 46u_L^2 u_0^2 + 24u_L u_0^3 + u_0^4}}{4(u_L+u_0)}$. Next we check whether the above roots are binding given that by assumption $0 < u_0 < u_L < u_H$. First, $u_L > \varphi^-$ if $-\sqrt{33u_L^4 - 88u_L^3 u_0 + 46u_L^2 u_0^2 + 24u_L u_0^3 + u_0^4} < -3u_L^2 + 8u_L u_0 - u_0^2$ and $u_L > \varphi^+$ if $\sqrt{33u_L^4 - 88u_L^3 u_0 + 46u_L^2 u_0^2 + 24u_L u_0^3 + u_0^4} < -3u_L^2 + 8u_L u_0 - u_0^2$. The right-hand side of these inequalities is positive for $u_L \in (u_0, 2.53u_0)$. If $u_L < 2.53u_0$ then $u_L > \varphi^-$ and either $u_L > \varphi^+$ or $\varphi^- < u_L < \varphi^+$, which happens for $u_L < \frac{5}{3}u_0$ and for $u_L > \frac{5}{3}u_0$, respectively. We conclude that for

$u_0 < u_L < \frac{5}{3}u_0$ then $u_L > \varphi^+ > \varphi^-$ and $B > 1$ regardless of the size of u_H; and for $\frac{5}{3}u_0 < u_L < 2.53u_0$ then $\varphi^- < u_L < \varphi^+$; therefore, $B > 1$ when $u_H > \varphi^+$ and $B < 1$ when $u_H < \varphi^+$. While if $2.53u_0 < u_L$ then $u_L < \varphi^+$ and either $\varphi^- < u_L$ or $u_L < \varphi^-$, which happens for $u_L > \frac{5}{3}u_0$ and for $u_L < \frac{5}{3}u_0$; respectively. The latter is a contradiction, hence $\varphi^- < u_L < \varphi^+$. And again $B > 1$ when $u_H > \varphi^+$ and $B < 1$ when $u_H < \varphi^+$. Summarizing the above discussion, we may distinguish three cases:

- when $u_0 < u_L < \frac{5}{3}u_0$ and for all u_H; $B > 1$
- when $\frac{5}{3}u_0 < u_L < u_H$ and $u_H > \varphi^+$, $B > 1$;
- when $\frac{5}{3}u_0 < u_L < u_H$ and $u_H < \varphi^+$, $B < 1$.

The above three cases give rise to parts i) and ii) in Proposition 3.

Finally, we prove Proposition 4. By lemma 1 the equilibrium outcome must belong to the subgames where the single-product manufacturer delegates sales. Thus, consider first when $\Pi_M^{AD} > \Pi_M^{ND}$. This happens iff

$$z_A((\tfrac{d_H}{d_L}); b) = 112(\tfrac{d_H}{d_L})^4 - 16(7 + 12b + 7b^2)(\tfrac{d_H}{d_L})^3 + 4(3 + 46b + 42b^2 + 3b^4)(\tfrac{d_H}{d_L})^2$$
$$- 4b(3 + 26b + 22b^2 + 26b^3 + 3b^4)(\tfrac{d_H}{d_L}) + b^2(3 + 20b + 18b^2 + 20b^3 + 3b^4) > 0$$

Some cumbersome algebra and numerical computations show that this is true.

Next, $\Pi_M^{HD} > \Pi_M^{AD}$ iff a quadratic polynomial of the profitability ratio is positive. In doing so we firstly check that the coefficient of the quadratic term in the polynomial is positive. This reduces to assessing the sign of the following function on $(\frac{d_H}{d_L})$ and b:

$(172800(\frac{d_H}{d_L})^7 - 576(93 + 2b(577 + 34b))(\frac{d_H}{d_L})^6 + 16(347 + 2b(5297+$

$2b(16787 + 12b(160 + 3b))))(\frac{d_H}{d_L})^5 - 16(12 + b(860 + b(13577 + 3b(19679+ b(3271 + 116b)))))(\frac{d_H}{d_L})^4 + 4b(86 + b(3308 + b(36098 + b(121938 + b(26180+ 1329b)))))(\frac{d_H}{d_L})^3 - 4b^2(57+b(1548+b(13149+b(37006+b(9628+627b)))))(\frac{d_H}{d_L})^2 +b^3(66 + b(1413 + b(9978 + b(24478 + 9b(824 + 65b)))))(\frac{d_H}{d_L}) - b^4(1 + 6b)(1 + b(6 + b))(7 + 3b(14 + 3b))$

By numerical computations we see that it is positive.

Secondly, we obtain the roots of the quadratic polynomial of the profitability ratio and prove that the discriminant is negative therefore concluding that the polynomial is always positive. The discriminant is negative i® the following function on $(\frac{d_H}{d_L})$ and b is negative:

$-29376(\frac{d_H}{d_L})^5 + 48(196 + 3b(640 + 49b))(\frac{d_H}{d_L})^4 - 48(21 + b(476 + b(2359+ b(353+9b)))))(\frac{d_H}{d_L})^3+4(9+b(432+b(4999+2b(8459+b(1853+90b)))))(\frac{d_H}{d_L})^2 - 12b(3 + b(78 + b(619 + b(1631 + b(466 + 33b)))))(\frac{d_H}{d_L}) + 3b^2(1 + 6b)(3 + 18b + 4b^2)(1 + b(6 + b))$

and again numerical computations show that the latter expression is negative.

Finally, it remains to compare $¦_M^{HD}$ with $¦_M^{LD}$: The former is greater than the latter i®:

$(d_L(2(1 + 4b)d_H - b(1 + 3b)d_L)(a_H - c_H) - (4d_H^2 - 2b(1 - 3b)d_H d_L - 2b^3 d_L^2)(a_L - c_L))$

$£(s_H(a_H - c_H) + s_L(a_L - c_L)) > 0$

The ¯rst term is positive whenever $\frac{(a_H - c_H)}{(a_L - c_L)} > \frac{(4d_H^2 - 2b(1-3b)d_H d_L - 2b^3 d_L^2)}{d_L(2(1+4b)d_H - b(1+3b)d_L)}$ which is the bound B in Proposition 4, where the bound B is greater or smaller than one depending on the cases relates in Proposition 3. The second is positive iff $\frac{(a_H - c_H)}{(a_L - c_L)} < \frac{s_L}{-s_H}$; where $s_L > 0$ and $s_H < 0$: Algebraic together with numerical computations show that $\frac{s_L}{-s_H}$ is greater than the upperbound on the profitability ratio which ensures positive outputs, and then, this second term is always positive. The result of Proposition 4 follows.

M_H \\ M_L	action N	action D
action N	$q_H^{NN} = \dfrac{2(a_H - c_H) - b(a_L - c_L)}{4d_H - bd_L}$ $q_L^{NN} = \dfrac{2d_H(a_L - c_L) - d_L(a_H - c_H)}{(4d_H - bd_L)d_L}$	$q_H^{ND} = \dfrac{(4d_H - bd_L)(a_H - c_H) - 2bd_H(a_L - c_L)}{4(2d_H - bd_L)d_H}$ $q_L^{ND} = \dfrac{2d_H(a_L - c_L) - d_L(a_H - c_H)}{2(2d_H - bd_L)d_L}$
action D	$q_H^{DN} = \dfrac{2(a_H - c_H) - b(a_L - c_L)}{2(2d_H - bd_L)}$ $q_L^{DN} = \dfrac{(4d_H - bd_L)(a_L - c_L) - 2d_L(a_H - c_H)}{4(2d_H - bd_L)d_L}$	$q_H^{DD} = \dfrac{2\left((4d_H - bd_L)(a_H - c_H) - 2bd_H(a_L - c_L)\right)}{(16d_H^2 - 12bd_H d_L + b^2 d_L^2)}$ $q_L^{DD} = \dfrac{2d_H\left((4d_H - bd_L)(a_L - c_L) - 2d_L(a_H - c_H)\right)}{(16d_H^2 - 12bd_H d_L + b^2 d_L^2)d_L}$

TABLE 1A. *Equilibrium quantities of game G_1.*

M_H \\ M_L	action N	action D
action N	$\Pi_H^{NN} = \frac{d_H\left(2(a_H - c_H) - b(a_L - c_L)\right)^2}{(4d_H - bd_L)^2}$ $\Pi_L^{NN} = \frac{\left(2d_H(a_L - c_L) - d_L(a_H - c_H)\right)^2}{d_L(4d_H - bd_L)^2}$	$\Pi_H^{ND} = \frac{\left((4d_H - bd_L)(a_H - c_H) - 2bd_H(a_L - c_L)\right)^2}{16d_H(2d_H - bd_L)^2}$ $\Pi_L^{ND} = \frac{\left(2d_H(a_L - c_L) - d_L(a_H - c_H)\right)^2}{8d_H d_L(2d_H - bd_L)}$
action D	$\Pi_H^{DN} = \frac{\left(2(a_H - c_H) - b(a_L - c_L)\right)^2}{8(2d_H - bd_L)}$ $\Pi_L^{DN} = \frac{\left((4d_H - bd_L)(a_L - c_L) - 2d_L(a_H - c_H)\right)^2}{16d_L(2d_H - bd_L)^2}$	$\Pi_H^{DD} = \frac{2(2d_H - bd_L)\left((4d_H - bd_L)(a_H - c_H) - 2bd_H(a_L - c_L)\right)^2}{(16d_H^2 - 12bd_H d_L + b^2 d_L^2)^2}$ $\Pi_L^{DD} = \frac{2d_H(2d_H - bd_L)\left((4d_H - bd_L)(a_L - c_L) - 2d_L(a_H - c_H)\right)^2}{d_L(16d_H^2 - 12bd_H d_L + b^2 d_L^2)^2}$

TABLE 1B. *Payoffs of game G_1. Delegation in a vertically differentiated duopoly.*

M1 \\ M2	action N	action D
action N	$q_1^{NN} = \frac{a_L - c_L}{3d_L}$ $q_2^{NN} = \frac{a_L - c_L}{3d_L}$	$q_1^{ND} = \frac{(4d_H - bd_L)(a_L - c_L) - 2d_L(a_H - c_H)}{4(2d_H - bd_L)d_L}$ $q_2^{ND} = \frac{2(a_H - c_H) - b(a_L - c_L)}{2(2d_H - bd_L)}$
action D	$q_1^{DN} = \frac{2(a_H - c_H) - b(a_L - c_L)}{2(2d_H - bd_L)}$ $q_2^{DN} = \frac{(4d_H - bd_L)(a_L - c_L) - 2d_L(a_H - c_H)}{4(2d_H - bd_L)d_L}$	$q_1^{DD} = \frac{2(a_H - c_H)}{5d_H}$ $q_2^{DD} = \frac{2(a_H - c_H)}{5d_H}$

TABLE 2A. *Equilibrium quantities of game G_2.*

M_1 \\ M_2	action N	action D
action N	$\Pi_1^{NN} = \frac{(a_L - c_L)^2}{9d_L}$ $\Pi_2^{NN} = \frac{(a_L - c_L)^2}{9d_L}$	$\Pi_1^{ND} = \frac{\left((4d_H - bd_L)(a_L - c_L) - 2d_L(a_H - c_H)\right)^2}{16(2d_H - bd_L)^2 d_L}$ $\Pi_2^{ND} = \frac{\left(2(a_H - c_H) - b(a_L - c_L)\right)^2}{8(2d_H - bd_L)}$
action D	$\Pi_1^{DN} = \frac{\left(2(a_H - c_H) - b(a_L - c_L)\right)^2}{8(2d_H - bd_L)}$ $\Pi_2^{DN} = \frac{\left((4d_H - bd_L)(a_L - c_L) - 2d_L(a_H - c_H)\right)^2}{16(2d_H - bd_L)^2 d_L}$	$\Pi_1^{DD} = \frac{2(a_H - c_H)^2}{25d_H}$ $\Pi_2^{DD} = \frac{2(a_H - c_H)^2}{25d_H}$

TABLE 2B. *Payoffs of game G_2. Endogeneous selection of quality by delegation.*

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