Product differentiation when "quality is a matter of tastes": the case of corporate social responsibility with asymmetric information[1]

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Abstract

To analyze the new phenomenon of competition in corporate social responsibility (CSR) we adopt a product differentiation approach in which the Hotelling segment is reinterpreted as the space of product SR characteristics and consumer tastes are uncertain. We find equilibria of the pure location and of the price-location games and show what changes when we move from a duopoly of profit maximizing producers to a mixed duopoly. Our findings illustrate that a nonzero degree of CSR is the optimal choice of profit maximizing corporations under reasonable parametric intervals of consumers' concern for SR, corporate cost of CSR and uncertainty about consumer tastes. Our model of location with unidirectional costs applied to competition in CSR may be generalised to a larger class of "hybrid" (horizontal/vertical) differentiation models in which the perception of a costly investment as a "quality" improvement is a matter of tastes.

1 Introduction

Corporate social responsibility (CSR) is an increasingly debated issue in contemporary market economies.[3] KPMG (2005) reports that, in the year 2005, 52 percent of the top 100 corporations in the 16 more industrialized countries published a CSR report. In a recent survey the "2003 Corporate social responsibility monitor"[4] finds that the amount of consumers looking at social responsibility in their choices jumped from 36 percent in 1999 to 62 percent in 2001 in Europe.

A simple way of modelling this novel feature of the economic environment is within differentiation models[5] by reinterpreting the space of product characteristics as the space of both firm CSR behavior and heterogeneous consumers'

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[3]For a reference to the most relevant positions in the historical debate evaluating causes and consequences of CSR see, among others, Friedman (1962) and Freeman (1984), while on the methodological problems arising when pursuing the goal of maximization of multiple stakeholders interests see, among others, Jensen (1986) and Tirole (2001).

[4]Downloadable at http://www.bsdglobal.com/issues/sr.asp.

[5]For a reference to the traditional literature on horizontal product differentiation see Hotelling (1929); D'Aspremont, Gabsewicz and Thisse (1979); Economides (1984) and Dasgupta and Maskin (1986), while for vertical differentiation the seminal paper is Shaked-Sutton

CSR beliefs. On the corporate side, since CSR is not a "free lunch" and implies a shift of focus from the maximization of shareholder wealth to the maximization of the interest of a wider set of stakeholders, we can model it as the payment of a variable premium over input costs.

This generalization may include various cases of compensation to stakeholders different from shareholders such as efficiency wages (Shapiro-Stiglitz, 1984), other types of monetary and non monetary benefits for workers, the adoption of environmental friendly but more costly productive processes, the introduction of code of conducts on labour conditions in subcontracting companies, etc. Within this framework we are interested in evaluating whether firms may find it optimal to choose CSR, even when it is modelled as a pure cost.[6] To do so we investigate three specific problems: i) the producers' optimal location choices in a duopoly in which firms maximize profits under uncertainty on consumer tastes; ii) the price-location equilibrium of the problem in i); iii) the price-location equilibrium in a mixed duopoly in which a profit maximizing producer competes with a not-for-profit organization.

The original contribution of our model consists of the introduction of the novel feature of CSR competition under consumer taste uncertainty in the classical product differentiation literature. The introduction of uncertainty acknowledges that one of the main problems in CSR is that of asymmetric information since producers do not know exactly consumers ethical tastes. This ingredient creates an inevitable element of noise which renders impossible to evaluate with precision the effect of CSR on producer market shares. Given our hypotheses, the closer reference in the literature to our model is that of De Palma, Ginsburgh, Papageorgiou and Thisse (1985), who calculate optimal location in a simple product differentiation model in presence of uncertainty about consumer tastes.

With respect to this paper (a part for modeling the new phenomenon of CSR explained above) our approach represents an original contribution also on a purely theoretical point of view. Consider in fact that, in our case, location has consequences on (CSR) costs (moving rightward is costly for producers as it implies paying higher SR costs) and therefore we may think of our approach as a model of localisation in which the Hotelling segment of the CSR product differentiation model is "upward sloped" for producers.

In this perspective our approach can be generalised to a larger class of "hybrid" differentiation models in which the perception of a costly investment as

(1983). In a synthesis of the two perspectives Craemer and Thisse (1991) show that location horizontal differentiation models can be considered as special cases of vertical differentiation models.

[6] As it is well known CSR costs may be compensated by other potential benefits (beyond that of the increased demand of concerned consumers which is explicitly considered in our model) such as the minimisation of conflicts of interest with stakeholders (Freeman, 1984), an improved signal on product quality in a framework of asymmetric information, increased workers motivation (Frey, 1997), etc. Nevertheless, the direct effect of the CSR choice, separated from these potential indirect positive effects, is likely to generate a reduction in corporate profits and therefore a model in which it is considered as a pure cost (which can be compensated by the increased demand of concerned consumers) has sound foundations.

a "quality" improvement is a matter of tastes (or is not equally appreciated by every consumer). Examples of it are i) the introduction of music entertainment or of video infrastructure for showing satellite sport programs into restaurants; ii) high speed trains which shorten travelling time but have reduced stability, thereby negatively affecting passenger opportunities of reading, writing and working on the train and more generally iii) new vintage technologies when users skills are complementary to the old vintage ones.

The paper is divided into five sections (introduction and conclusion included). In the second section we shortly describe model characteristics. In the third section we outline the pure location equilibrium. In the fourth the price-location equilibrium, while in the fifth section we examine departures from the latter when we move from a duopoly to a mixed oligopoly.

2 The model

In our "CSR product differentiation" model the two producers locate on the point $x \in [0,1]$ of the market segment according to their degree of SR. On the right (left) boundary of the SR space the duopolists pay the maximum (minimum) amount of SR costs s (0) and, as far as producers move rightward, they become more SR and pay a higher x-portion of the maximum cost s. Non SR costs are set to zero - as in De Palma et al. (1985) - without lack of generality. The product is sold at a given price p. Consumers have inelastic unit demands and are uniformly distributed along the [0,1] interval of the SR space X. Consumer locations are denoted by $x \in X$ and measured as distances from the origin of the segment. More specifically, we formulate the utility function of a consumer located in x and purchasing from firm i as follows:[7]

$$v_i[x] = b - p - f\,|x - x_i| \tag{1}$$

where b is the consumer's reservation value of the product when his ethical standards coincide with those incorporated in the product and f is the weight given to the disutility of consuming a product whose ethical standards are below one's own standards.[8]

[7] Empirical support for our hypothesis on the heterogeneity of individual attitudes toward social responsibility (implied by the symmetric cost of SR distance) is confirmed by descriptive evidence from the World Value Survey database - 65,660 (15,443) individuals interviewed between 1980 and 1990 (1990 and 2000) in representative samples of 30 (7) different countries. In both surveys around 45 (49) percent of sample respondents declare that they are not willing to pay in excess for the environmentally responsible features of a product. The same survey documents that the share of those arguing that the poor are to be blamed is around 29 percent in both surveys. This simple evidence confirms heterogeneity in the willingness to pay for social and environmental responsibility, rejecting the assumption that more of SR may be better for all individuals.

[8] The cost of ethical distance has a clear monetary counterpart. When the producer is located at the left of the consumer this cost represents the distance in monetary terms between

Firms can not predict consumers' behavior *a priori*, but they can determine the utility of a consumer located in x as:

$$u_i[x] = v_i[x] + \mu\varepsilon_i \tag{2}$$

where ε_i is a random variable with zero mean and unit variance and μ is a positive constant. Heterogeneity in consumer tastes is indicated by μ, which weights the unknown terms of the probabilistic utility function. The higher is μ, the larger is the stochastic term of the utility function.

2.1 The location model

In this first simplified version of the model we assume that two profit maximizing producers have unit prices and compete in the market, with location being their only choice variable.

Following De Palma et al. (1985) and Manski et al. (1981), we assume that the ε_i terms are identically, independently Weibull-distributed, so that the probability that a consumer located in x will buy from firm i is:

$$P_i[x] = \frac{e^{(b-p-f|x-x_i|)/\mu}}{\sum_{j=1}^{2} e^{(b-p-f|x-xj|)/\mu}} \tag{3}$$

When both producers choose their locations, we identify three regions on the ethical segment (the first at the left of the less ethical producer, the second in between the two producer locations and the third at the right of the more ethical producer). We therefore define the probability of purchasing from producer 1 for consumers respectively located in regions 1, 2 or 3 as follows:

$$P_1^1 = \frac{1}{1+H}, \qquad P_1^2 = \frac{1}{1+e^{-(f/\mu)(\delta+2(x_1-x))}}, \qquad P_1^3 = \frac{1}{1+K} \tag{4}$$

where $\delta = |x_1 - x_2|$, $H = \exp(-f\delta/\mu)$ and $K = \exp(f\delta/\mu)$. Hence, the first and the last probabilities are invariant in x, while the second is decreasing in x since $\frac{\partial P_1^2}{\partial x} < 0$. By evaluating the second derivative we can find the inflexion point $\overline{x} = x_1 + \frac{\delta}{2}$.

For $x_1 < x < x_1 + \frac{\delta}{2}$ the probability function is concave and, for $x_1 + \frac{\delta}{2} < x < x_2$, it is convex, its shape depending also on the amount of μ. The higher is μ, the flatter is the function as it is shown in figure 1 ($\mu_2 > \mu_1$). The figure clearly shows that a higher weight on the stochastic term has the effect of reducing "location rents" of the two producers.

the CSR engagement (measured by the CSR cost in our model), which is considered fair by the consumer (indicated by his location on the segment) and the CSR cost suffered by the producer (indicated by producer's location on the segment). The coefficient t maps this objective measure into consumers preferences indicating whether its impact on consumers utility is proportional (t=1), more than proportional (t>1) or less than proportional (t<1) than its amount in monetary terms.

Let us define as Agglomerated Nash Equilibrium (ANE) a Nash equilibrium in which both locations coincide. By using this definition we can formulate the following proposition.

Proposition 1: A location maximization problem of two competing producers in a market with ethical consumers has a unique Agglomerated Nash Location Equilibrium given by $x_1 = x_2 = \frac{1}{2} - \frac{2\mu s}{f}$.

Proof:

Given assumptions 1 and 2, and letting $p = 1$, we can evaluate the profit of firm 1 as follows:

$$\begin{aligned} \pi_1(x_1) &= \int_0^{x_1} P_1^1[x]dx + \int_{x_1}^{x_2} P_1^2[x]dx + \int_{x_2}^{1} P_1^3[x]dx - sx_1 = \\ &= \frac{x_1}{1+H} + \frac{\delta}{2} + \frac{1-x_2}{1+K} - sx_1 \end{aligned} \tag{5}$$

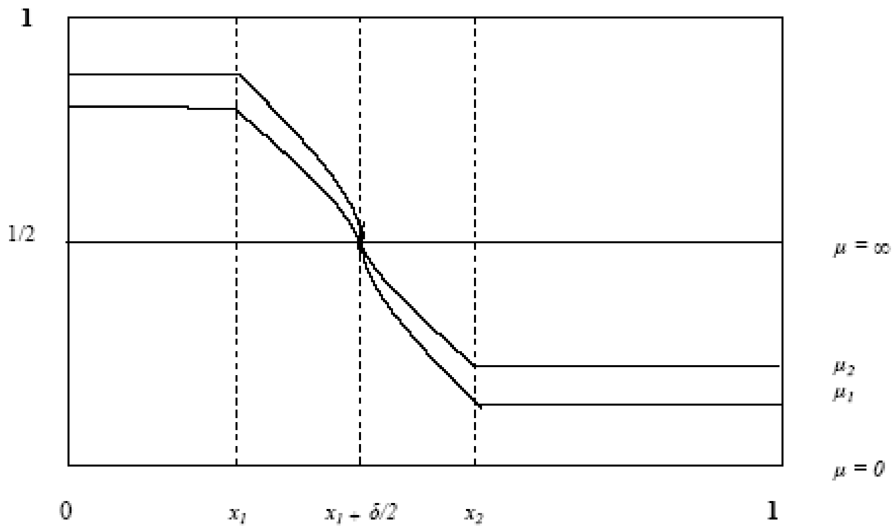

Figure 2.1.1. Legend: on the horizontal axis we measure the market segment in which the two producer locations x_1 and x_2 delimit three consumer regions. On the vertical axis we measure the probability that the consumer located in the corresponding point of the market segment buys from firm 1.

We can consider s as a parameter which defines the rectangle of ethical costs in figure 2.1.1. The problem can be solved by considering $x_2 > x_1$ and, symmetrically, the same results can be obtained when $x_2 < x_1$. To analyze the best location reply (BLR) of firm 1 given the location of firm 2 we evaluate the following derivative:

$$\frac{d\pi_1(x_1)}{dx_1} = \frac{\mu(K-H) + 2f(1-x_1-x_2)}{2\mu(1+K)(1+H)} - s = 0 \tag{6}$$

symmetrically, the BLR of firm 2 relative to firm 1 is

$$\frac{d\pi_2(x_2)}{dx_2} = \frac{\mu(H-K) + 2f(1-x_1-x_2)}{2\mu(1+K)(1+H)} - s = 0 \tag{7}$$

Since the two functions are symmetric, they intersect on the line $x_1 = x_2 = x^*$. Thus, it is easy to show that the Nash equilibrium of the game is given by the following location on the ethical segment:

$$x^* = \frac{1}{2} - \frac{2\mu s}{f}. \tag{8}$$

The solution in (8) can be a Nash equilibrium if it is positive, or if the following parametric condition holds:

$$s < \frac{f}{4\mu}$$

The solution is a maximum since second order conditions are respected, with second derivatives, evaluated in $x = 1/2 - 2\mu s/f$, being always negative:[9]

$$\left.\frac{d^2\pi_1}{dx_1^2}\right|_{x_1=x_2=\frac{1}{2}-\frac{2\mu s}{f}} = \frac{-2f\left[K(1-s)+H(1+s)+2\right]}{\mu(1+K)^2(1+H)^2} < 0. \tag{9}$$

$$\left.\frac{d^2\pi_2}{dx_2^2}\right|_{x_1=x_2=\frac{1}{2}-\frac{2\mu s}{f}} = \frac{-2f\left[K(1+s)+H(1-s)+2\right]}{\mu(1+K)^2(1+H)^2} < 0.\square \tag{10}$$

The interpretation of our proposition is that profit maximizing firms will choose nonzero CSR if the ratio between consumer sensitiveness to CSR and uncertainty on the heterogeneity of consumer tastes is above a given threshold.

To compare our results with the standard one of Hotelling (1929) consider that the minimum differentiation principle applies also here but the optimal location of the two producers is shifted to the left with respect to the standard

[9] The numerator of $\frac{d^2\pi_1}{dx_1^2}$ is
$\{2f\mu\left[-K-H-2\right](1+K)(1+H)-$
$-2\left[-fK(1+H)+fH(1+K)\right]\left[\mu(K-H)+\right.$
$+2f(1-x_1-x_2)/4\mu^2(1+K)^2(1+H)^2$. Since the denominator is always positive we consider the numerator, which is $\left\{-8f\mu(K+H+2)+4f^2(1-x_1-x_2)(K-H)\right\}$, and, substituting $x = \frac{1}{2} - \frac{2\mu s}{f}$, we have the expression in (9).

The numerator of $\frac{d^2\pi_2}{dx_2^2}$ is
$2f\mu\left[-K-H-2\right](1+K)(1+H)-$
$-2f\left[K(1+H)-H(1+K)\right]\left[\mu(H-K)+\right.$
$\left.+2f(1-x_1-x_2)\right] =$
$= \left\{-8f\mu(K+H+2)+4f^2(1-x_1-x_2)(H-K)\right\}$, and, substituting $x = \frac{1}{2} - \frac{2\mu s}{f}$, we have the expression in (10).

case without SR, in which they locate in $\frac{1}{2}$. This is because the duopolists find their Nash equilibrium by choosing the same location but their segment is "upward sloping" since they feel the increasing effects of the ethical costs as far as they move to the right.

As expected, the optimal location depends positively on the consumer sensitiveness to CSR (f) and negatively on the precision with which the producer may identify consumer tastes (measured by the μ parameter). Finally, the optimal location obviously depends from the inclination of the slope, or from the amount of transfers s: the higher is s, the more expensive is moving rightward on the segment.

2.2 The price model

In this section we want to investigate what happens in our model when the two producers have fixed location and compete in prices. The analysis of the model under these assumptions may be considered unrealistic, but is a preliminary tool which is necessary, as we will see in the following section, to illustrate the equilibrium when the two producers compete in both location and prices.[10]

The model under the above described characteristics leads us to formulate the following proposition.

Proposition 2: In a market with SR concerned consumers a price maximization problem of two competing PMPs has a unique Agglomerated Nash Price Equilibrium given by $p_1 = p_2 = 2\mu$.

Proof:

Since producer locations coincide the probability that a consumer located in x buy from firm i is simply:

$$P_i = \frac{e^{-p_i/\mu}}{\sum_{j=1}^{2} e^{-p_j/\mu}} \tag{11}$$

As a consequence, profits of firm 1 and firm 2 will be

$$\pi_1(p_1) = p_1 \int_0^1 \frac{1}{1+e^{(p_1-p_2)/\mu}} dx = \frac{p_1}{1+e^{(p_1-p_2)/\mu}} \tag{12}$$

$$\pi_2(p_2) = p_2 \int_0^1 \frac{1}{1+e^{(p_2-p_1)/\mu}} dx = \frac{p_2}{1+e^{(p_2-p_1)/\mu}} \tag{13}$$

with the following first order conditions

[10] The stronger justification for the price model is that the two producers may decide to collude. In this case their optimal choice may be zero (or a minimum common level of) CSR and a common price policy with a commitment to avoid price undercutting strategies à la Bertrand. All other rationales for an exogenous level of CSR (prohibitive costs of implementation of CSR standards in some specific industries or discontinuities in the choice of the CSR stance which prevent firms to deviate from a unique discrete choice) may also contribute to justify the price model in itself, beyond its instrumental role in explaining the price-location model which follows.

$$\frac{d\pi_1}{dp_1} = \frac{(1+e^{(p_1-p_2)/\mu}) - \frac{1}{\mu}p_1 e^{(p_1-p_2)/\mu}}{\left(1+e^{(p_1-p_2)/\mu}\right)^2} = 0 \quad (14)$$

$$\frac{d\pi_2}{dp_2} = \frac{(1+e^{(p_2-p_1)/\mu}) - \frac{1}{\mu}p_2 e^{(p_2-p_1)/\mu}}{\left(1+e^{(p_2-p_1)/\mu}\right)^2} = 0 \quad (15)$$

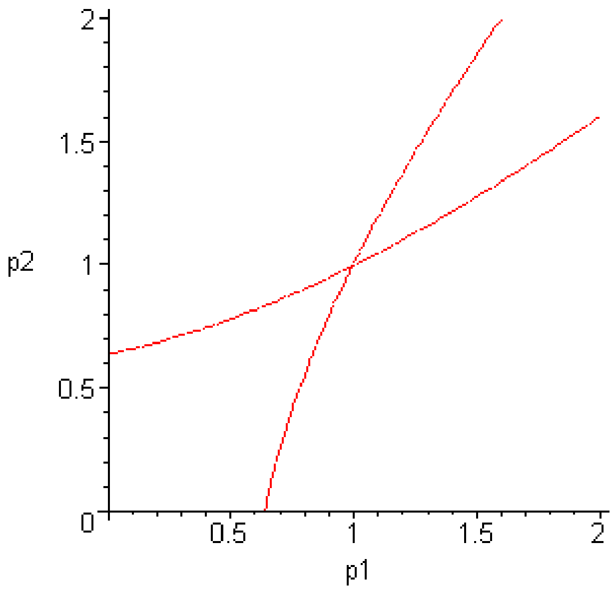

Figure 2.2.1

This means that the two price reaction functions, $\frac{d\pi_1}{dp_1}(\cdot)$ and $\frac{d\pi_2}{dp_2}(\cdot)$, are symmetric in the p_1, p_2 plan with respect to the bisector, so they cross on the bisector itself, as shown in Figure 2.2.1. For this reason we can easily find a unique price Nash equilibrium $p_1 = p_2 = p$ such that $2\mu - p = 0$ implying $p = 2\mu$.

This solution is a maximum since, by checking second order conditions, we evaluate the second derivative for firm 1 in the solution:

$$\frac{d\pi_1}{dp_1}(p_1) = \frac{\frac{1}{\mu}\left\{-\frac{p_1}{\mu}e^{\lambda}(1+e^{\lambda}) - 2e^{\lambda}(1+e^{\lambda}) + 2e^{2\lambda}\frac{p_1}{\mu}\right\}}{(1+e^{\lambda})^3}$$

Substituting $p_1 = 2\mu$ we have

$$\left.\frac{d\pi_1}{dp_1}\right|_{p_1=2\mu} = -\frac{1}{2\mu} < 0$$

In the same way we can derive the second order conditions for firm 2, obtaining

$$\left.\frac{d\pi_2}{dp_2}\right|_{p_2=2\mu} = -\frac{1}{2\mu} < 0.\square$$

To interpret the equilibrium of the model consider that, in the price model, a higher μ implies an increase in the variance of the random component (or more variability in the distribution of consumer tastes) leading to an increase in prices when firms are located in the same point of the interval. The interpretation is that consequences of the magnification of the random component in the consumer utility function are asymmetric. More specifically, consumers may accept to buy at higher price, while the negative consequences of higher prices for the producer, as far as μ grows, are bounded. In other words, the marginal benefit of a price rise for a producer (in terms of consumer surplus extraction) is always positive as far as μ grows, while, on the other direction, the consumer may simply decide not to buy the product without determining increasing losses to the producer as far as μ grows.

2.3 The location-price model

In this section we analyze the model under the assumption that producers compete by choosing both CSR location and prices. Thus, producer 1 calculates that a consumer located in the regions 1, 2 or 3 will respectively purchase his product with the following probabilities:

$$P_1^1 = \frac{1}{1+e^{\lambda}H}, \qquad P_1^2 = \frac{1}{1+e^{\lambda-(f/\mu)(\delta+2(x_1-x))}}, \qquad P_1^3 = \frac{1}{1+e^{\lambda}K} \quad (16)$$

where $\lambda = \frac{p_1-p_2}{\mu}$. Again, the first and the last probabilities are constant, while the second is decreasing in x, since $\frac{\partial P_1^2}{\partial x} < 0$.

Within this framework it is possible to formulate the following proposition:

Proposition 3: In a location-price maximization problem of two competing PMPs in a market with ethical consumers whose ethical concerns are such that $f > \max\left(\frac{s^2}{2\mu}, 2s\right)$, *there is an Agglomerated Nash Equilibrium given by* $x_1 = x_2 = \frac{1}{2} - \frac{s}{f}$ and $p_1 = p_2 = 2\mu$.

Proof:

We can write firm 1 and firm 2 profits respectively as:

$$\begin{aligned} \pi_1(x_1,p_1) &= p_1 \left\{ \int_0^{x_1} P_1^1[x]dx + \int_{x_1}^{x_2} P_1^2[x]dx + \int_{x_2}^{1} P_1^3[x]dx \right\} - sx_1 = \\ &= p_1 \left\{ \frac{x_1}{1+e^{\lambda}H} + \delta - \frac{\mu}{2f} \ln\left(\frac{1+e^{\lambda}K}{1+e^{\lambda}H}\right) + \frac{1-x_2}{1+e^{\lambda}K} \right\} - sx_1 \end{aligned} \quad (17)$$

and:

$$\pi_2(x_2,p_2) = p_2\left\{\int_0^{x_1} P_2^1[x]dx + \int_{x_1}^{x_2} P_2^2[x]dx + \int_{x_2}^{1} P_2^3[x]dx\right\} - sx_2 =$$
$$= p_2\left\{\frac{x_1}{1+e^{-\lambda}K} + \delta + \frac{\mu}{2f}\ln\frac{1+e^{-\lambda}H}{1+e^{-\lambda}K} + \frac{1-x_2}{1+e^{-\lambda}H}\right\} - sx_2 \qquad (18)$$

The optimal choice for firm 1 is obtained by evaluating first order conditions when $x_2 > x_1$ (and symmetrically for the opposite case):

$$\frac{\partial\pi_1(x_1,p_1)}{\partial p_1} = \frac{x_1\left(1+e^{\lambda}H(1-p_1/\mu)\right)}{(1+e^{\lambda}H)^2} + \frac{(1-x_2)(1+e^{\lambda}K(1-p_1/\mu))}{(1+e^{\lambda}K)^2} +$$
$$+ \quad \delta - \frac{\mu}{2f}\left\{\ln\left(\frac{1+e^{\lambda}K}{1+e^{\lambda}H}\right) + \frac{e^{\lambda}(K-H)p_1/\mu}{(1+e^{\lambda}K)(1+e^{\lambda}H)}\right\} = 0 \qquad (19)$$

$$\frac{\partial\pi_1(x_1,p_1)}{\partial x_1} = -s + p_1\left\{\frac{1+e^{\lambda}H\left(1-\frac{f}{\mu}x_1\right)}{(1+e^{\lambda}H)^2} - 1+\right. \qquad (20)$$
$$\left. + \frac{e^{\lambda}}{2}\frac{K(1+e^{\lambda}H)+H(1+e^{\lambda}K)}{(1+e^{\lambda}H)(1+e^{\lambda}K)} + \frac{f}{\mu}e^{\lambda}K\frac{1-x_2}{(1+e^{\lambda}K)^2}\right\} = 0$$

Firm 2 first order conditions are:

$$\frac{\partial\pi_2(x_2,p_2)}{\partial p_2} = \frac{x_1\left(1+e^{-\lambda}K(1-p_2/\mu)\right)}{(1+e^{-\lambda}K)^2} + \frac{(1-x_2)(1+e^{-\lambda}H(1-p_2/\mu))}{(1+e^{-\lambda}H)^2}$$
$$+ \quad \delta + \frac{\mu}{2f}\left\{\ln\left(\frac{1+e^{-\lambda}H}{1+e^{-\lambda}K}\right) + \frac{e^{-\lambda}(H-K)p_2/\mu}{(1+e^{-\lambda}K)(1+e^{-\lambda}H)}\right\} = 0 \qquad (21)$$

$$\frac{\partial\pi_2(x_2,p_2)}{\partial x_2} = -s + p_2\left\{\frac{-\frac{f}{\mu}e^{-\lambda}Kx_1}{(1+e^{-\lambda}K)^2} + 1+\right.$$
$$-\frac{e^{-\lambda}}{2}\frac{H(1+e^{-\lambda}K)+K(1+e^{-\lambda}H)}{(1+e^{-\lambda}H)(1+e^{-\lambda}K)} -$$
$$\left. + \frac{1+e^{-\lambda}H\left(1-\frac{f}{\mu}(1-x_2)\right)}{(1+e^{-\lambda}K)^2}\right\} = 0 \qquad (22)$$

If an agglomerated Nash equilibrium exists, the following equality $x_1 = x_2 = x$ should hold in it. Hence, as a first step, we can easily turn back to the price problem where we fixed both locations and found solutions for prices. As a second step, we may use the price problem result ($p_1 = p_2 = 2\mu = p$) in eq. (20) to find an agglomerated location solution ($x_1 = x_2 = x$). The common location has to verify the necessary condition to be a Nash equilibrium, given by eq. (20) and (**??**):

$$-s + 2\mu \left\{ \frac{1}{2} - \frac{fx}{4\mu} - 1 + \frac{1}{2} + \frac{f(1-x)}{4\mu} \right\} = 0 \tag{23}$$

By adopting the above mentioned approach we obtain the following outcome

$$x' = \frac{1}{2} - \frac{s}{f} \tag{24}$$

and we can easily verify that this last solution satisfies also first order conditions of firm 2.

The sufficient condition is given by the Hessian matrix of the problem for firm 1 and for firm 2 evaluated at x':

$$HES_1 = HES_2 = \begin{bmatrix} -f & \frac{s}{2\mu} \\ \frac{s}{2\mu} & -\frac{1}{2\mu} \end{bmatrix}$$

$$\det(HES_1) = \det(HES_2) = \frac{f}{2\mu} - \frac{s^2}{4\mu^2};$$

This means that solution (24) is a Nash equilibrium if $f > \frac{s^2}{2\mu}$ holds. By combining this condition with the one which ensures a positive solution ($f > 2s$), we finally have the more general condition of $f > \max\left(\frac{s^2}{2\mu}, 2s\right)$.□

Remark: Proposition 3 ensures that an ANE exists, but we don't know if it is the unique Nash equilibrium of the problem.

This result can be obtained also by considering this problem as a location problem with price $p \neq 1$. Just by multiplying the first term in eq. (6) and in eq. (7) by 2μ, we have the same result as in (24).

A computation using particular values of parameters can help us to see if that agglomerated equilibrium is unique. In particular, when $\mu = 1$ and $f = 1$, we can easily verify that, after a few steps, all variables converge to their theoretical value, as shown in Table 2.3.1.

In Table 2.3.1 we have two different sets of initial parameters. In the first one, with $s = 0.25$, by starting with null values for all variables, we suppose that the two competitors maximize their profits by observing values of each other variables. In this case firm 1 maximizes first, thereby triggering firm 2 optimal reaction and so on. After 9 steps all values stabilize and reach solutions (x', p). In the second scenario, with $s = 0.45$ and the same sequence of moves, variables converge after 12 steps to the solution (x', p) as well.

$s = 0.25;\ \mu = 1;\ f = 1;\ x' = \frac{1}{2} - \frac{s}{f} = 0.25;\ p = 2$						
Step	x_1	x_2	p_1	p_2	π_1	π_2
1	0	0	0	0	0	0
2	0		1.28		0.278464	
3		0.213		1.75		0.69089
4	0.235		1.88		0.825927	
5		0.242		1.945		0.88218
6	0.25		2		0.912038	
7		0.25		2		0.9375
8	0.25		2		0.9575	
9		0.25		2		0.9575
$s = 0.45;\ \mu = 1;\ f = 1; x' = \frac{1}{2} - \frac{s}{f} = 0.05; p = 2$						
Step	x_1	x_2	p_1	p_2	π_1	π_2
1	0	0	0	0	0	0
2	0		1.28		0.278464	
3		0		1.67		0.674208
4	0		1.84		0.841988	
5		0.035		1.938		0.922144
6	0.044		1.973		0.953526	
7		0.047		1.987		0.966748
8	0.048		1,994		0.972362	
9		0.049		1.998		0.975402
10	0.05		2		0.976951	
11		0.05		2		0.9775
12	0.05		2		0.9775	

Table 2.3.1

If we compare the optimal level of CSR in the location and in the price-location game we find that CSR is higher in the latter. More specifically, the parameters s and f influence the optimal location choice as in the pure location model, but this time the result does not depend on the uncertainty on consumer tastes. This is because, with the price variable, producers may also get benefits from higher variability of consumer tastes by extracting the surplus from those with high reservation prices. The opportunity to use prices together with location allows them to choose relatively more CSR than in the pure location model for a given level of uncertainty on consumer tastes.

3 Mixed duopoly

In many cases CSR competition originates from entry of a SR, non profit maximizing, "pioneer" which triggers the reaction of the incumbent profit maximizing producer through partial CSR imitation. To check whether the presence of the pioneer has some relevance with respect to a duopoly of two profit maximizing firms we find it useful to analyze what happens in terms of CSR when we move from our previous model to a mixed oligopoly in which one of the two producers is profit maximizing and the other is not.

A typical example of a zero profit producer triggering SR imitation of profit maximising producers may be that of the Fair Trader (FT).[11] His ethical stance consists of transferring the whole profit to the subcontractees which are represented by marginalised raw material producers being paid with a subsistence wage by profit maximising producers. As a consequence his profit will be zero and his maximization problem concerns transfers instead of profits. Thus the FT has to choose a location in the ethical segment by maximizing total transfers T. The latter are given by the sum of the PMP's transfer plus the FT's profit, which will be totally transferred: [12]

$$T(x_2, p_2) = p_2 \left\{ \frac{x_1}{1+e^{-\lambda}K} + \delta + \frac{\mu}{2f} \ln \left(\frac{1+e^{-\lambda}H}{1+e^{-\lambda}K} \right) + \frac{1-x_2}{1+H} \right\} + sx_1 \quad (25)$$

In this framework we are going to investigate what happens on player 2 if player 1 becomes "closer" to a FT, or if it decides to maximize CSR costs (transfers) and to study the behavior of variables around the initial optimal solution (x', p) found in the two PMP case.

Intuitively, in order to become a FT, the firm will move to the right in the ethical segment. This happens because the function of transfers grows when location x_2 increases from the initial point, as its derivative with respect to x_2 evaluated in (x', p) is positive:

$$\left. \frac{\partial T_2}{\partial x_2}(x_2, p_2) \right|_{x',p} = 2\mu \left(-\frac{f}{8\mu} + \frac{s}{4\mu} + \frac{f}{8\mu} + \frac{s}{4\mu} \right) = s > 0 \quad (26)$$

[11] Fair traders compete with traditional producers and distributors by selling food and textile products which incorporate social and environmentally responsible characteristics and have the goal of fostering inclusion of marginalised producers in the South. The 2005 European Fair Trade Report illustrates that fair trade sales have grown by 20 percent per year in the last five years and have reached significant market shares in some specific segments (i.e. 49 percent of bananas in Switzerland and 20 percent of ground coffee in the UK). After fair traders' entry on the market large transnationals have partially imitated them by introducing similar products in their product range. According to BBC news, on October the 7th, 2000 Nestle has launched a fair trade instant coffee as it looks to tap into growing demand among consumers. The BBC comments the news saying that "Ethical shopping is an increasing trend in the UK, as consumers pay more to ensure poor farmers get a better deal." and reports the comment of Fiona Kendrick, Nestle's UK head of beverages arguing that "Specifically in terms of coffee, fair trade is 3 percent of the instant market and has been growing at good double-digit growth and continues to grow." One of the world's biggest players in the coffee market, the US consumer good company Procter & Gamble, announced it would begin offering Fair Trade certified coffee through one of its specialty brands. Following Procter & Gamble's decision to start selling a Fair Trade coffee, also Kraft Foods, committed itself to purchasing sustainably grown coffee. On the theoretical debate of the role and impact of Fair Trade at micro and aggregate level see also Becchetti and Solferino (2004), Hayes (2004), Leclair (2002) and Moore (2004).

[12] The case of a "selfish" Fair Trader maximising his own transfers instead of market transfers may be equally interesting but is omitted here for reasons of space.

Before looking at market equilibrium with a mixed duopoly where one of the two PMPs is now a zero profit producer located at the extreme right of the segment, we are therefore interested to see what happens when the change is only partial and one of the two PMPs moves slightly to the right. The analysis of this case leads us to formulate the following proposition

Proposition 4: In a market with ethical consumers with $f > \max\left(\frac{s^2}{2\mu}, 2s\right)$, *and two competing PMPs maximizing their profit in the location* $x' = \frac{1}{2} - \frac{s}{f}$, *if firm 2 moves slightly to the right on the ethical segment, there will be a small reduction of location and price of firm 1.*

Proof:

To analyze the effects of this increase in x_2 with the second producer moving from the initial point to the right, we consider the first order conditions with respect to the other variables, recalling eq. (20) and (19) for firm 1:

$$\begin{aligned}\pi_{1_{p_1}}(x_1, p_1) &= \frac{x_1\left(1+e^{\lambda}H(1-p_1/\mu)\right)}{(1+e^{\lambda}H)^2} + \frac{(1-x_2)(1+e^{\lambda}K(1-p_1/\mu))}{(1+e^{\lambda}K)^2} + \\ &+ \delta - \frac{\mu}{2f}\left\{\ln\left(\frac{1+e^{\lambda}K}{1+e^{\lambda}H}\right) + \frac{e^{\lambda}(K-H)p_1/\mu}{(1+e^{\lambda}K)(1+e^{\lambda}H)}\right\} = 0\end{aligned}$$

$$\begin{aligned}\pi_{1_{x_1}}(x_1, p_1) &= -s + p_1\left\{\frac{1+e^{\lambda}H\left(1-\frac{f}{\mu}x_1\right)}{(1+e^{\lambda}H)^2} - 1 + \right. \\ &\left. + \frac{e^{\lambda}}{2}\frac{K(1+e^{\lambda}H)+H(1+e^{\lambda}K)}{(1+e^{\lambda}H)(1+e^{\lambda}K)} + \frac{f}{\mu}e^{\lambda}K\frac{1-x_2}{(1+e^{\lambda}K)^2}\right\} = 0\end{aligned}$$

$$\begin{aligned}T_{2_{p_2}}(x_2, p_2) = &\ \frac{\partial}{\partial p_2}\pi_2(x_2, p_2) = \frac{x_1\left(1+e^{-\lambda}K(1-p_2/\mu)\right)}{(1+e^{-\lambda}K)^2} + \\ + &\ \frac{(1-x_2)(1+e^{-\lambda}H(1-p_2/\mu))}{(1+e^{-\lambda}H)^2} + \delta + \\ + &\ \frac{\mu}{2f}\left\{\ln\left(\frac{1+e^{-\lambda}H}{1+e^{-\lambda}K}\right) + \frac{e^{-\lambda}(H-K)p_2/\mu}{(1+e^{-\lambda}K)(1+e^{-\lambda}H)}\right\} = 0\end{aligned}$$

As these derivatives are null in the initial point (optimum for the two PMP case), we can apply the Implicit Function Theorem and evaluate the effects of variables with respect to each other in that point. Hence we have

$$
\begin{aligned}
\left.\frac{\partial x_1}{\partial p_1}\right|_{x',p} &= -\left.\frac{\frac{\partial \pi_{1_{x_1}}}{\partial p_1}}{\frac{\partial \pi_{1_{x_1}}}{\partial x_1}}\right|_{x',p} = \frac{s}{2f\mu};\ \left.\frac{\partial p_2}{\partial p_1}\right|_{x',p} = -\left.\frac{\frac{\partial T_{2_{p_2}}}{\partial p_1}}{\frac{\partial T_{2_{p_2}}}{\partial p_2}}\right|_{x',p} = \frac{1}{2};\\
\left.\frac{\partial x_1}{\partial p_2}\right|_{x',p} &= -\left.\frac{\frac{\partial \pi_{1_{x_1}}}{\partial p_2}}{\frac{\partial \pi_{1_{x_1}}}{\partial x_1}}\right|_{x',p} = 0;\ \left.\frac{\partial p_1}{\partial p_2}\right|_{x',p} = -\left.\frac{\frac{\partial \pi_{1_{p_1}}}{\partial p_2}}{\frac{\partial \pi_{1_{p_1}}}{\partial p_2}}\right|_{x',p} = \frac{1}{2};\\
\left.\frac{\partial p_1}{\partial x_1}\right|_{x',p} &= -\left.\frac{\frac{\partial \pi_{1_{p_1}}}{\partial x_1}}{\frac{\partial \pi_{1_{p_1}}}{\partial p_1}}\right|_{x',p} = s;\ \left.\frac{\partial p_2}{\partial x_1}\right|_{x',p} = -\left.\frac{\frac{\partial T_{2_{p_2}}}{\partial x_1}}{\frac{\partial T_{2_{p_2}}}{\partial p_2}}\right|_{x',p} = -s;\\
\left.\frac{\partial x_1}{\partial x_2}\right|_{x',p} &= -\left.\frac{\frac{\partial \pi_{1_{x_1}}}{\partial x_2}}{\frac{\partial \pi_{1_{x_1}}}{\partial x_1}}\right|_{x',p} = 0;\ \left.\frac{\partial p_1}{\partial x_2}\right|_{x',p} = -\left.\frac{\frac{\partial \pi_{1_{p_1}}}{\partial x_2}}{\frac{\partial \pi_{1_{p_1}}}{\partial p_1}}\right|_{x',p} = -s;\\
\left.\frac{\partial p_2}{\partial x_2}\right|_{x',p} &= -\left.\frac{\frac{\partial T_{2_{p_2}}}{\partial x_2}}{\frac{\partial T_{2_{p_2}}}{\partial x_2}}\right|_{x',p} = s; \qquad (27)
\end{aligned}
$$

As we can see a higher x_2 generates a price change (p_1 decreases and p_2 increases). A reduction of p_1 generates a reduction of x_1 and a further change in prices. If we organize this process in sequential steps, given the FT decision to move x_2 slightly to the right ($\Delta x_1 = h$) we can define as a_i, b_i and c_i respectively $\Delta x_1, \Delta p_1$ and Δp_2 in the step i. Hence we have

$$
\begin{aligned}
a_1 &= 0,\quad b_1 = -sh,\quad c_1 = sh\\
a_2 &= \frac{s}{2f\mu}b_1,\quad b_2 = sa_1 + \frac{1}{2}c_1,\quad c_2 = -sa_1 + \frac{1}{2}b_1\\
&\vdots\\
a_n &= \frac{s}{2f\mu}b_{n-1},\quad b_n = sa_{n-1} + \frac{1}{2}c_{n-1},\quad c_n = -sa_{n-1} + \frac{1}{2}b_{n-1} \qquad (28)
\end{aligned}
$$

By defining the following vector

$$
y_n = \begin{pmatrix} a_n \\ b_n \\ c_n \end{pmatrix} \qquad (29)
$$

we have

$$
y_n = Fy_{n-1} \qquad (30)
$$

where

$$
F = \begin{pmatrix} 0 & \frac{s}{2f\mu} & 0 \\ s & 0 & \frac{1}{2} \\ -s & \frac{1}{2} & 0 \end{pmatrix} \qquad (31)
$$

If F has 3 distinct real eigenvalues then every solution y_n of the system of linear difference equation (30) tends to 0 as $n \to \infty$ if and only if all the eigenvalues of F have absolute value less than 1.

In fact the eigenvalues solving

$$\det(\lambda I - F) = 0 \tag{32}$$

are $\lambda_1 = \frac{1}{2}$; $\lambda_2 = \frac{1}{4}\frac{-f\mu+\sqrt{f^2\mu^2+8f\mu s^2}}{f\mu}$; $\lambda_3 = \frac{1}{4}\frac{-f\mu-\sqrt{f^2\mu^2+8f\mu s^2}}{f\mu}$, which are real distinct and $|\lambda_i| < 1$, $i = 1, ..., 3$.

Hence, to solve our problem we are going to evaluate the following series

$$\sum_{n=1}^{\infty} y_n$$

To this aim we consider

$$\sum_{n=2}^{N} y_n = F\sum_{n=2}^{N} y_{n-1} = F\sum_{n=1}^{N-1} y_n \tag{33}$$

.

We add $y_1$to both sides and can rearrange it as

$$y_N + (I - F)\sum_{n=1}^{N-1} y_n = y_1 \tag{34}$$

and

$$(I - F)^{-1}y_N + \sum_{n=1}^{N-1} y_n = (I - F)^{-1}y_1 \tag{35}$$

For $N \to \infty$, $(I - F)^{-1}x_N \to 0$.

Since by (31)

$$\det(I - F) = \frac{-s^2 + 3f\mu}{4f\mu}\left(\frac{1}{4}\right) \neq 0 \tag{36}$$

we can evaluate $(I - F)$ and we can write

$$\sum_{n=1}^{\infty} y_n = (I - F)^{-1}\, y_1 = \begin{pmatrix} \frac{3f\mu}{3f\mu-s^2} & \frac{2s}{3f\mu-s^2} & \frac{s}{3f\mu-s^2} \\ \frac{2sf\mu}{3f\mu-s^2} & \frac{4f\mu}{3f\mu-s^2} & \frac{2f\mu}{3f\mu-s^2} \\ \frac{-2sf\mu}{3f\mu-s^2} & \frac{2(f\mu-s^2)}{3f\mu-s^2} & \frac{2(2f\mu-s^2)}{3f\mu-s^2} \end{pmatrix} y_1 \tag{37}$$

The final increments around the point (x', p) are

$$\sum_{n=1}^{\infty} a_n = \Delta x_1 = -\frac{s^2 h}{3f\mu - s^2} \quad (38)$$

$$\sum_{n=1}^{\infty} b_n = \Delta p_1 = -\frac{2f\mu sh}{3f\mu - s^2} \quad (39)$$

$$\sum_{n=1}^{\infty} c_n = \Delta p_2 = \frac{2f\mu sh}{3f\mu - s^2} \quad (40)$$

Hence, after a small variation of x_2 to the right, the PMP moves slightly to the left, reducing his price and conquering a greater market share of less ethical consumers. The PMP which has increased its SR raises his price to cover the added costs due to his ethical stance (sx_2).□

$s = 0.25;\ \mu = 1;\ f = 1;\ x = \frac{1}{2} - \frac{s}{f} = 0.25;\ p = 2$					
x_1	x_2	p_1	p_2	π_1	π_2
0.25	0.25	2	2	0.9375	0.9375
	1		2		0.97291
0.261		2.158		1.033169	
	1		2.0422		1.04766
0.265		2.18		1.054757	
	1		2.0512		1.05832
0.2654		2.1848		1.059389	
	1		2.0533		1.06065
0.2656		2.186		1.060472	
	1		2.054		1.061234
0.2656		2.186		1.060832	
$s = 0.45;\ \mu = 1;\ f = 1; x = \frac{1}{2} - \frac{s}{f} = 0.05; p = 2$					
x_1	x_2	p_1	p_2	π_1	π_2
0.05	0.05	2	2	0.9775	1.0225
	1		2.058		1.001176
0.049		2.134		1.030588	
	1		2.14		1.065875
0.061		2.179		1.071489	
	1		2.141		1.08818
0.061		2.18		1.071993	
	1		2.142		1.088676
0.061		2.18		1.042798	

Tabel 3.1

Consider that this finding is not at odd with the minimum differentiation result described with proposition one. This is because the first deviation from the equilibrium of one of the two producers is not an optimal deviation in the profit maximisation perspective, but a deviation which depends on the transformation of producer's goals (which leads to a change of the model from the original duopoly to a mixed oligopoly).

Consider however that, when facing greater variation of x_2, the PMP decides to move to the right as well and increases his price. For example, recalling the scenarios described in the previous section, we suppose that the FT decides to locate in $x_2 = 1$ from the initial point (x', p). The reaction of the PMP from the initial point (x', p) is indicated in Table 3.1.

As we can see this time the PMP has to move to the right, otherwise he would lose his market share. To cover the higher costs of CSR he has to increase his price too. The tables show that when a firm become a FT locating at the right extreme of the segment, even the other firm becomes more ethical and moves to the right.

4 Conclusions

The last decade witnessed a significant expansion of CSR practices of the most important corporations, with many of them advertising their advances in this field in order to conquer the increasing share of "concerned" consumers. CSR, as many other aspects of the economic reality, suffers from the typical problem of asymmetric information. Many consumers wonder whether firms engaged in CSR really do what they advertise, while the same firms try to understand whether consumers will give weight to CSR in their demand functions and/or believe to their declared CSR stance. For these reasons we argue that a product differentiation model in which the traditional Hotelling segment is reinterpreted as the space of CSR product characteristics in presence of uncertainty on consumer tastes is the best candidate to analyze this emerging form of competition.An advantage of our analytical approach is that it can represent a theoretical benchmark for many other problems of product differentiation in which producers costly invest on a product feature which is not unanimously perceived as a quality improvement by all consumers.

What we learn within this theoretical framework is that the minimum differentiation principle, the standard result in location games without uncertainty, applies also here, except that location is not in the middle of the segment but shifted to the left. The rationale is that moving to the right (becoming more SR) entails costs for producers which may be recovered only if consumers have sufficiently strong preferences for the CSR product. Hence producers will opt for nonzero CSR only if these costs and consumers uncertainty are sufficiently low. More interestingly, we find that also the price-location model has an agglomerated Nash equilibrium when consumer preferences for CSR are sufficiently high. CSR will be higher in the price-location than in the pure location game since producers may extract consumer surplus and remunerate with higher prices their CSR stance. A final result of the model is that when we move from the duopoly of profit maximizing firms to a mixed oligopoly in which one of the two behaves as a not-for-profit organisation (as fair trade producers do) the level of

CSR of his competitor becomes also higher. This final result is consistent with the history of CSR competition among fair traders and big transnationals which started imitating the former by introducing fair trade products in their product range.

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