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Good and *Bad* Increases in Ecological Awareness: Environmental Differentiation Revisited*

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ABSTRACT

We analyze a vertically differentiated market, assuming that *conventional* and *green* firms' products have different impacts on the environment. Heterogeneous consumers choose to be supplied by a conventional or a green firm, depending on their extra willingness to pay for a green product and the relative prices of the products in the market. We show that environmental awareness campaigns may have a negative impact on total welfare. This possibility is shown to exist without consumer misperceptions about the quality of green products and ruling out changes in the coverage and the structure of the market. Surprisingly, both conventional and green firms may benefit from heterogeneity-enhancing awareness campaigns, while social welfare is more likely to be enhanced by heterogeneity-reducing ones.

Keywords: Vertical differentiation, WTP for green products, environmental awareness campaigns.

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INTRODUCTION

In their role as consumers, citizens of developed countries are becoming increasingly aware of the problems associated with the deterioration of the environment due to the

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functioning of the market. As a consequence, they exhibit some preference for green products and processes, expressed in an increased willingness to pay (WTP) for them. In modern societies, economic policy needs to be innovative as to the instruments that should be used in order to favor the emergence of the desired outcomes. Beyond taxes and subsidies, governments increasingly use advertising techniques in order to educate citizens with principles leading the society and the economy along the desired path. It is commonly accepted as obvious that increasing the consumers' awareness towards environmental issues is monotonically beneficial for the society and profitable for green producers. For example, Endres (1997) proposes the use of state campaigns aimed at awakening people's ecological awareness. However, there are only a few studies focusing on the negative effects that such campaigns may have on the economic and environmental performance of product markets.

To our knowledge, the social desirability of increasing the consumers' ecological awareness has been already challenged, mainly on the basis of two arguments: first, consumers' wrong perception of a green product's quality and, second, the monopolization or incomplete coverage of the market due to consumer awareness-related advantages gained by green firms in the market. In the following paragraphs, we review these two arguments and briefly describe a totally different argument which is formalized in this paper.

The first argument against the universal desirability of increasing the consumer's ecological awareness is proposed by Conrad (2005) in the framework of a horizontally differentiated duopoly. The author argues that the social value of the environmental damage caused by marketed products may be overestimated by the consumer. In that case, an information campaign aimed at *increasing* the consumer's willingness to pay for ecological products would be socially undesirable. We will refer to this argument as the *consumer misperception* argument. Our approach differs from that of Conrad (2005) in two ways. First, we assume that environmental differentiation is of the vertical rather than of the horizontal type. That is, rather than letting consumers have different ideal varieties, we assume that consumers unanimously accept the superiority of the green product over its conventional substitutes, although they differ in their willingness to pay for a *greener* product. Second, rather than comparing consumers' heterogeneous and, in general, erroneous perception of a product's environmental damage with an exogenously imposed correct one, we assume that consumers only differ in their WTP for an improvement in a product's environmental quality but not in the perception of the quality itself. With respect to this second difference between our framework and that in Conrad (2005), we feel that our approach has the advantage that it does not suffer from the problem of showing the existence of socially undesirable ecological awareness, based on an exogenously imposed discrepancy between objective and subjective environmental quality differences.

The vertical differentiation framework which we adopt here is related to the model recently introduced in García-Gallego and Georgantzís (2009). Apart from their difference in the way in which qualities are reflected on production costs, the two papers differ from each other in the arguments offered on the reason why increases in the consumers' ecological awareness may be socially undesirable. Specifically, in García-Gallego and Georgantzís (2009) it is shown that increasing the consumers' ecological awareness

may have two effects on the resulting market outcome. First, it may lead from complete to incomplete market coverage. That is, consumers' increased willingness to pay for a product's environmental quality may lead to higher equilibrium prices, at which some of the consumers cannot buy the good at all. Second, increasing the consumers' ecological awareness may imply a sufficiently large advantage to a green firm, for it to become a monopolist in the market. We will refer to the possibility of incomplete market coverage and that of market monopolization under the generic term *changes in market structure* or, simply, *structural changes*. Whereas we feel that the possibility of such structural changes may be relevant for many markets, there is a plethora of cases in which the aforementioned structural changes are very unlikely to occur, following an increase in the consumers' ecological awareness. For example, in the real world, consumers may substitute one product with another based on their environmental consciousness and the relative prices of alternative products in the market, but it is more difficult to find examples of consumers not buying a certain good at all because of an increase in their ecological awareness. Similarly, it is rather difficult to find examples of markets monopolized by the greenest manufacturer, following an increase in consumers' ecological awareness.

Numerous studies report results on hypothetical and revealed measures of WTP for ecological products.[1] A look at few recent examples confirms two stylized facts which are central to our analysis. First, consumers are heterogeneous with respect to their WTP for ecological products.[2] Second, there is an increasing trend of consumers world-wide to prefer ecological products over their standard (non-ecological) substitutes.[3]

We adopt the first of these two facts — consumer heterogeneity — as an assumption in a model which can be used to obtain the conditions for profitability and social desirability of increasing the consumer's WTP for ecological products.[4] Taste heterogeneity is assumed in most theoretical models studying the role of consumers' ecological awareness on market equilibrium. Heterogeneity may concern consumers' WTP for ecological product attributes, as in Moraga-González and Padrón-Fumero (2002), or some other consumer-specific feature like their income, as in Arora and Gangopadyhay (1995) and Bansal and Gangopadyhay (2003) or their ideal product variety, as in Conrad (2005). The theoretical framework most frequently used to reach economic and environmental policy recommendations is that of vertical product differentiation attributed to Mussa and Rosen (1978). All these studies take the distribution of tastes as given, in order to reach

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[1] For example, Camacho *et al.* (2004), elicit hypothetical and incentive compatible WTP for a recyclable office table, showing that survey data are a good predictor of a consumer's median WTP for an improvement in the environmental performance of a product.

[2] The existence and causes of such heterogeneity are studied, for example, in Daniere (1994), Blamey (1997), Loureiro and Lotade (2005). Nyborg's (2000) framework provides a theoretical background for such differences in ecological consciousness as combinations of *homo oeconomicus* and *homo politicus* in a consumers' utility function.

[3] Pham and Rambo (2003), Harris (2006), Suzuki *et al.* (2004) and Tsagarakis and Georgantzís (2002) document the increasing trend of ecological consciousness in four different countries: Vietnam, China, Japan and Greece, respectively. In fact, the last two explicitly deal with the role of information in people's willingness to accept costlier options favoring environment friendlier market outcomes.

[4] This assumption relates to similar ones adopted by von der Fehr and Stevik (1998) and Bloch and Manceau (1999) to model persuasive advertising in a framework of horizontal differentiation.

recommendations concerning other more orthodox policy instruments, like minimum environmental quality standards, environmental taxes and subsidies.[5]

Our analysis pays special attention to increases in consumers' ecological awareness, which may affect the heterogeneity of tastes. We show that private profitability is, generally speaking, enhanced by changes in the consumer's WTP for ecological products, if such changes increase consumer heterogeneity. On the contrary, social welfare is more likely to be enhanced by increases in the consumer's WTP leading to lower degrees of consumer heterogeneity. Campaigns targeted towards increasing the ecological awareness of the most environmentally conscious consumers will be of the heterogeneity-enhancing type, whereas increasing the least environmentally conscious consumers' WTP for ecological products will typically reduce consumer heterogeneity. We show that the socially undesirable type of WTP changes will often benefit producers of both *green* and *brown* products. The policy implications of this argument are straightforward: the state cannot rely upon private campaigns aiming at increasing the consumer's ecological awareness, because firms would benefit from increasing consumer heterogeneity by funding campaigns targeting the most environmentally conscious of the consumers. On the contrary, state campaigns should aim at increasing the ecological awareness of the least environmentally conscious consumers.

The paper is organized in the following way: The first section presents the model and the main results. In the second section, we discuss the robustness of our results with respect to several generalizations. The final section concludes.

THE MODEL

Two firms, a and b, sell two products which are identical in all other aspects, except for their performance with respect to the natural environment. In fact, the two product's environmental performances are assumed to be, respectively, S_a and S_b, which are engineering (objective) measures of the reduction in the negative impact of each product unit on the environment. Therefore, a product's environmental performance is assumed to correspond to a positive rather than a negative[6] number measuring the reduction in the environmental damage caused by a green product compared to that caused by a unit of the standard product. Given the assumption of our model concerning the complete coverage of the market by the sales of the two products, implying constant overall consumption, this measure quantifies the marginal reduction in the total environmental

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[5] See for example, Constantatos and Sartzetakis (1999) on environmental taxes, Motta and Jacques François (1999) on environmental quality standards, Nadaï and Morel (1999) on ecolabeling. On these policy instruments Lyon and Maxwel (2002) provide a very insightful overview with special emphasis on the existing empirical findings.

[6] That is, following the terminology in Garella and Lambertini (1999), environmental performance is a *good* rather than a *bad* characteristic and could represent, for example, the inverse of a product's undesirable environmental externality, or, as we assume here, as the reduction in the negative externality of each product unit on the environment due to a product's better environmental performance.

damage as compared to the case in which the market would be fully covered by the sales of the standard product, in which case the overall damage would be maximized. Without loss of generality, a is the *green* product, while the environmental performance of the standard product, b, is normalized to zero. That is, $S_a > S_b = 0$.

The population of potential (and actual, given the full market coverage assumption) consumers is M. Each consumer i maximizes her utility U_i, demanding a *maximum* of one unit of product from firm $j \in \{a, b\}$ whose product quality and price satisfy:

$$U_i = \max\{R + v_i \cdot S_a - P_a, R - P_b, 0\} \tag{1}$$

where $R > 0$ is the utility enjoyed by the consumer from consuming one product unit, before the difference in the two products' environmental qualities is taken into account. That is, apart from standard consumption utility, R also accounts for the consumers' loss of utility from consuming a product which damages the environment, but not for the consumer's extra "*feel-good*" effect emerging from the consumption of the less damaging environmentally friendly product. This is heterogeneous and is modeled by the consumer-specific parameter v_i capturing consumer i's WTP for a marginal improvement in the green product's environmental quality. The parameter is uniformly distributed along the interval $[m, n]$ $(m \geq 0, n > m)$ with density d. We introduce the notation $L = n - m$, which is the length of the segment along which consumer tastes are uniformly distributed or, alternatively, the consumer heterogeneity parameter. Note that $d \cdot (n - m) = d \cdot L = M$. The term P_j denotes the price fixed by firm j. Furthermore, we assume that R and S_a are sufficiently high, so that, in equilibrium, the possibility of consumers with zero consumption or firms with zero sales is ruled out.[7] Then, for a pair of prices (P_a, P_b) which are not too different from each other, there will be a consumer i_0, whose environmental consciousness parameter $v_0 \in [m, n]$, makes her indifferent between the green and the standard product:

$$v_0 \cdot S_a - P_a = -P_b \Rightarrow v_0 = \frac{P_a - P_b}{S_a} \tag{2}$$

Any consumer with $v < v_0$ $(v > v_0)$ will feel that the price difference is too high (low) as compared with the environmental performance difference between the two products and she will buy the standard (green) variety. We use this fact and Equation (2) to write the two firms' demands:

$$\begin{aligned} q_a &= (n - v_0) \cdot d = \left[n - \frac{P_a - P_b}{S_a} \right] \cdot d \\ q_b &= (v_0 - m) \cdot d = \left[\frac{P_a - P_b}{S_a} - m \right] \cdot d \end{aligned} \tag{3}$$

[7] García-Gallego and Georgantzís (2009), based on Liao (2008), observe that full market coverage outcomes will not emerge in equilibrium if environmental quality is reflected on fixed production costs, while they may emerge in equilibrium if quality affects variable production costs, which is the assumption made here.

Unit and total production costs are assumed to be zero, except for c which is an *extra unit production cost* paid by the manufacturer of the more ecological product. Using this assumption and the expressions in Equation (3), we obtain the corresponding profit functions:

$$\begin{aligned} \Pi_a &= (P_a - c) \cdot \left[n - \frac{P_a - P_b}{S_a} \right] \cdot d \\ \Pi_b &= P_b \cdot \left[\frac{P_a - P_b}{S_a} - m \right] \cdot d \end{aligned} \tag{4}$$

Firms set prices to maximize individual profits. The corresponding Bertrand–Nash equilibrium will satisfy the standard first order conditions giving rise to the system of reaction functions:

$$\begin{aligned} \partial \Pi_a / \partial P_a = 0 \Rightarrow P_a &= \frac{c + n \cdot S_a + P_b}{2} \\ \partial \Pi_b / \partial P_b = 0 \Rightarrow P_b &= \frac{P_a - m \cdot S_a}{2} \end{aligned} \tag{5}$$

whose solution yields the following equilibrium prices:

$$\begin{aligned} P_a^e &= \frac{1}{3} \left[2 \cdot c + (2n - m) \cdot S_a \right] \\ P_b^e &= \frac{1}{3} \left[c - (2m - n) \cdot S_a \right] \end{aligned} \tag{6}$$

and the corresponding equilibrium outputs:

$$\begin{aligned} q_a^e &= d \cdot \frac{(2n - m) \cdot S_a - c}{3 \cdot S_a} \\ q_b^e &= d \cdot \frac{c - (2m - n) \cdot S_a}{3 \cdot S_a} \end{aligned} \tag{7}$$

Equilibrium outputs will be positive as long as $2n - m > c/S_a > 2m - n$. That is, the extra unit cost of the green product is neither too high nor too low relative to the corresponding improvement in environmental performance for the green or the standard product, respectively, to be driven out of the market. This condition guarantees that, in equilibrium, there will be a consumer who is indifferent between the two products (or that both firms have positive sales). That is, $m < v_0^e = \frac{(m+n)}{3} + \frac{c}{3S_a} < n$. The condition is necessary for our analysis to be meaningful, given that we do not consider discontinuities like, for example, the case in which one of the two firms is driven out of the market, emerging when the indifferent consumer's taste coincides with one of the extremes of the support of consumer preferences.

Then, equilibrium profits are given by:

$$\Pi_a^e = d \cdot \frac{[(2n-m)\cdot S_a - c]^2}{9 \cdot S_a}$$
$$\Pi_b^e = d \cdot \frac{[c-(2m-n)\cdot S_a]^2}{9 \cdot S_a} \tag{8}$$

We observe that, while equilibrium quantities and profits depend on consumer density (and the total population of consumers), equilibrium prices and, thus, the environmental awareness of the *indifferent* consumer depend on relative rather than absolute characteristics of consumer distributions. Observation of equilibrium magnitudes in expressions (6)–(8) reveals the standard properties of this family of vertical product differentiation duopoly, according to which the high quality firm has a higher price, a higher market share and, thus a higher equilibrium profit than its low quality competitor.

Profitability of Changes in the WTP of Consumers

First, we study the effect of changes in the WTP of consumers on firms' profits. As stated earlier, we concentrate on three types of WTP's changes: (1) those which increase the environmental awareness, without affecting consumer heterogeneity, (2) changes that increase the consumers' environmental consciousness and, at the same time, increase consumer heterogeneity and (3) changes that increase the consumers' environmental awareness but decrease consumer heterogeneity.

The population density $d = M/(n-m)$ may, also, be expressed in terms of $L = (n-m)$ as $d = M/L$. It will be useful to write equilibrium profits as a function of M, m and L, in order to study changes in WTP affecting equally the WTP of all consumers, which corresponds to an increase in m, keeping M and L constant (first type):

$$H_a^e(m,L) = M \cdot \frac{[(m+2L)S_a - c]^2}{9 \cdot L \cdot S_a}$$
$$H_b^e(m,L) = M \cdot \frac{[c-(m-L)S_a]^2}{9 \cdot L \cdot S_a} \tag{8.1}$$

The same expressions can be used to study changes in WTP which increase consumer heterogeneity modeled as an increase in L, keeping m and M constant (second type).

Finally, it will be useful to write profits in terms of m, n and M in order to study changes in WTP which decrease consumer heterogeneity modeled as an increase in m, keeping n and M constant (third type):

$$\Pi_a^e(m,n) = M \cdot \frac{[(2n-m)\cdot S_a - c]^2}{9 \cdot (n-m) \cdot S_a}$$
$$\Pi_b^e(m,n) = M \cdot \frac{[c-(2m-n)\cdot S_a]^2}{9 \cdot (n-m) \cdot S_a} \tag{8.2}$$

Then, the derivatives of the expressions in (8.1) with respect to m, first, and then with respect to L would give us the effect of the first two types of changes on firms' profits for a given population $M$of consumers:

$$\begin{aligned}
\partial H_a^e/\partial m &= 2M \cdot \frac{[(m+2L)\cdot S_a - c]}{9L} \\
\partial H_b^e/\partial m &= 2M \cdot \frac{[(m-L)\cdot S_a - c]}{9L} \\
\partial H_a^e/\partial L &= -M \cdot \frac{[(m+2L)\cdot S_a - c]\cdot[(m-2L)\cdot S_a - c]}{9\cdot S_a \cdot L^2} \\
\partial H_b^e/\partial L &= -M \cdot \frac{[(m+L)\cdot S_a - c]\cdot[(m-L)\cdot S_a - c]}{9\cdot S_a \cdot L^2}
\end{aligned} \tag{9.1}$$

Similarly, the derivatives of the expressions in (8.2) with respect to m will give us the effect of the third type of changes on firms' profits, for a given M:

$$\begin{aligned}
\partial \Pi_a^e/\partial m &= M \cdot \frac{[c - m\cdot S_a]\cdot[c-(2n-m)\cdot S_a]}{9\cdot S_a\cdot(n-m)^2} \\
\partial \Pi_b^e/\partial m &= M \cdot \frac{[c-(3n-2m)\cdot S_a]\cdot[c-(2m-n)\cdot S_a]}{9\cdot S_a\cdot(n-m)^2}
\end{aligned} \tag{9.2}$$

From the signs of the derivatives in Equations (9.1) and (9.2) and some simple algebra we reach our main result concerning private profitability:

Proposition 1 *Firm a always benefits from WTP's changes of the first two types. The third type will benefit firm a, only if* $m \cdot S_a > c$. *With respect to firm b, the first and the third types of WTP's changes will always reduce its profits. The second type will benefit firm b if* $n \cdot S_a > c$.

Following this result, in order for both firms to benefit from WTP's changes increasing the heterogeneity of consumers (second type), the most environmentally aware consumer in the market must sufficiently value the superiority of the green product to justify the extra production costs paid by the manufacturer of the green product. This is a rather weak condition as compared to the condition for profitability of the third type of WTP changes for the green firm. It requires that the *least* environmentally aware among the consumers, to be willing to pay for a unit of the green product more than the extra unit cost of producing it. In fact, if a better environmental performance is not reflected on unit production costs, that is $c = 0$, the former of the two conditions holds always, whereas the latter of the conditions is never satisfied.

In the real world, the actual trends definitely favor increases in WTP for ecological products. As we have argued, these trends may have different effects on consumers with different attitudes towards the product's characteristics. Proposition 1 shows that the effect of a certain WTP change on consumer heterogeneity will determine its profitability. According to Proposition 1, under reasonably general conditions, both firms benefit from changes increasing consumer heterogeneity, whereas none of them would gain

from changes decreasing consumer heterogeneity, unless a rather strong condition holds, under which the manufacturer of the more ecological between the two products benefits only. On the contrary, firms have opposite interests with respect to changes in WTP leaving consumers heterogeneity unchanged. As we would have expected, changes in consumers' WTP which uniformly increase all consumers' environmental awareness, benefits the green firm and harms the conventional one. In order to gain intuition on the comparative statics driving these results, we should have in mind that consumers' heterogeneity plays a similar role to product differentiation. When consumers are more heterogeneous, the power of the two firms over their corresponding segments of the market increases, and competition is relaxed.

Predictions Concerning Observable Data: Prices and Market Shares

Although the main focus of the paper concerns the profitability and social desirability of increasing the consumers' ecological awareness, we briefly[8] review here some straightforward comparative statics of our model concerning other observable magnitudes like prices and market shares.

Interestingly, only changes of the second type increase the price of both the products. The first type has opposite effects on the two products' equilibrium prices. As we would have expected, changes which uniformly increase all consumers' WTP for quality, will increase the price of the green product and decrease the price of the brown one. Changes of the third type in consumers' WTP increase competition between the two firms by decreasing consumer heterogeneity, thus decreasing equilibrium prices. In all cases, increases in the WTP for ecological products will increase the difference between equilibrium prices.

The green firm's market share weakly increases in the presence of any of the three types of changes considered here. In the case of type 1 changes, the positive relation between the green firm's price and market share explains a fact often reported in empirical work on differentiated markets. A combination of lower prices and higher market shares in the case of the third type would be compatible with the contrary phenomenon, that is, a negative correlation between market shares and prices. However, this phenomenon would be reversed, if relative, rather than absolute, prices were taken into account. In the presence of type 3 changes, it is the increase in the green firm's market share that may compensate (under the first condition in Proposition 1) the firm's losses due to lower prices and make this type of changes profitable for the green firm. A similar correlation between market shares and prices is expected to emerge in equilibrium for the conventional firm. Therefore, we would expect a far more systematic (positive) correlation between market shares and relative (rather than absolute) prices.

Future empirical studies could be guided by these predictions on observable data.

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[8] Given that all the comparative statics discussed here are straightforward consequences of obtaining the sign of the derivatives of equilibrium magnitudes with respect to the corresponding parameters of the model, we omit the analytical derivation of these results which are available upon request from the authors.

Social Welfare Implications

In order to discuss welfare and policy implications of our results, we will need to calculate social welfare. Expressed in monetary units, this will be given by consumers' total WTP for the standard product ($M \cdot R$) minus the objectively evaluated fixed environmental damage, D, reduced by the damage avoided due to the consumption of the green product, net of the corresponding extra production cost. To this, we must add the extra surplus enjoyed by the consumers of the environmentally friendly product due to the feel-good effect from green consumption which raise their WTP for it in the first place. Given that this effect does not make consumers deviate from selfish utility maximization, yielding a higher surplus to more ecologically conscious consumers, it cannot be considered to be a *commitment* in the sense of Sen's (1977) famous paper on rational fools. In fact, in terms of the approach by Harsanyi (1955), the aforementioned effect is the part of the consumers' subjective extra welfare from the consumption of environmentally friendly products, which is not accounted for in the objective (engineering) evaluation of the damage avoided due to green consumption. Finally, observe that, with full market coverage, prices are an internal monetary transfer from consumers to producers, with no effect total social welfare.

It is important to notice that the social welfare calculated below is measured in monetary units, like is each one of its three main components: total WTP for the standard product; the environmental damage net of the reduction due to green consumption, which in its turn is net of the corresponding extra costs; and the overall feel-good effect perceived by the consumers of the green product. The expression of the social welfare function in terms of monetary units allows us to make meaningful comparisons between the states *before* and *after* the change in consumers' environmental consciousness takes place.

Combining the elements described above, we express below social welfare in terms of m and L. Some algebra gives us the following expression (10):

$$SW = \overbrace{M \cdot R}^{\substack{\text{Overall}\\ \text{WTP}\\ \text{for}\\ \text{stndrd.prod}}} - \overbrace{\left[D - \underbrace{d \cdot (S_a - c) \cdot (m + L - v_0)}_{\substack{\text{Damage}\\ \text{redctn.}-\\ \text{redctn. cos}\, t}} \right]}^{\text{Env.Damage}} + \overbrace{d \cdot \int_{v_0}^{m+L} v S_a dv}^{\substack{\text{“Feel}-\text{good”}\\ \text{effect}\\ \text{from}\\ \text{green}\\ \text{consumptn.}}}$$

$$(\text{from (2)}) = M \cdot R - D + d \times \left[(S_a - c) \cdot \left(m + L - \frac{P_a - P_b}{S_a} \right) + \frac{S_a}{2} \cdot \left((m+L)^2 - \frac{(P_a - P_b)^2}{S_a^2} \right) \right]$$

Provided that the result obtained from our welfare analysis aims at offering an illustration of the deviation between private and social benefits from increasing consumers' WTP for the green product, we simplify the analysis by introducing the normalization: $S_a = 1$. Then, the condition for survival of both firms in equilibrium becomes: $m < c < n$, which implies a plausible situation in which the most environmentally aware consumer believes that the extra cost of producing the ecological product is justified, whereas the least environmentally aware one believes it is not. Remember that this assumption corresponds to the interesting case according to which the second type of WTP changes positively correlates with both firms' equilibrium profits.

With all this in mind, we reach our main result concerning the welfare implications of changes in the consumers' WTP for a more ecological product:

Proposition 2 *If (and only if)* $m > m^* = \frac{5c-7L-3}{5}$, *social welfare is positively affected by WTP changes of the first type. Similarly, if (and only if)* $L > L^* = \sqrt{\frac{(c-m)[5(c-m)-6]}{8}}$, *social welfare is positively affected by WTP changes of the second type. Finally, the third type of changes in WTP has an unambiguous positive effect on social welfare.*

Therefore, the third type of changes in WTP is the only one of the three types considered here which has an unambiguously positive effect on social welfare. The other two types behave in a qualitatively similar way to each other. That is, increasing the consumer's WTP for the environmental performance of a product is unambiguously socially desirable, as long as the consumers are, initially, willing to pay a sufficiently high price for it.

Note that the assumptions under which we study social welfare ($n > c > m$), together with Proposition 1, imply that the third type of changes in WTP cannot be profitable for firm a and that the second type is unambiguously profitable for b. Under these conditions, we can interpret the preceding welfare analysis in terms of compatibility between private and social incentives:

- As far as changes in m are concerned (for a given degree L of consumer heterogeneity), any effort undertaken by firm b (firm a) in order to decrease (increase) the consumer's marginal WTP for quality is socially desirable, as long as $m < m^*$ ($m > m^*$).

Also, let us define $L^{**} = c - m$, which is obtained from Proposition 1, by rearranging the condition: $c < (m + L) \cdot S_a$ and substituting $S_a = 1$. Then,

- Regarding changes in L, both firms' interests would be (in)compatible with higher levels of social welfare if $L > L^{**}$ ($L < L^*$), whereas, for $L^* < L < L^{**}$, only the green firm's profitability is compatible with higher levels of social welfare.

As shown in the Appendix, m^* and L^* correspond to local *minima* of equilibrium social welfare. In the cases in which m^*, L^* fail to fall within the ranges required by the conditions of the model, social welfare is unambiguously positively affected by changes of the first two types.

Therefore, private and social incentives may coincide only for high degrees of initial taste dispersion.

- Finally, although changes of the third type are — under the assumptions made here — unambiguously socially desirable, our results predict that firms will not make any effort favoring this type of change.

EXTENSIONS — GENERALIZATIONS

We provide here some discussion on the robustness of our main results with respect to modifications and generalizations of the model, concentrating on a simplified version of it, in which $m = 0$. Detailed calculations are provided only when necessary for the reader to follow our arguments. Most details on the analytical derivation of several straightforward results are omitted here and are available upon request.

Market-Expanding WTP Changes

From equilibrium profits in (8), we can study the effect of changes that increase the total number of consumers, M. This corresponds to the case in which a better performance of a product with respect to the environment or public campaigns, aiming at convincing people that this is so, increases the total number of consumers. It may equally correspond to a case in which the market grows due to any type of advertising or, even due to exogenous demographic factors. We can summarize the most interesting implication of our model for this type of market-expanding changes considering the simplified version of the model assumed throughout this section, although the result stated below can be easily shown to hold under significantly less restrictive assumptions.

For the special case in which the more ecological firm achieves its environmental performance at no extra cost (due to an intrinsic characteristic of the firm, rather than as the result of a costly environmental performance improving process), that is, if $c = 0$, it is easy to see that:

- *Any growth of the market (higher* $\boldsymbol{M}$*) in favor of a more environmentally aware consumer population (higher* $\boldsymbol{L}$*) benefits both firms, whereas both firms may even benefit from a decrease in the consumer population (lower* $\boldsymbol{M}$*) in favor of a more environmentally oriented market (higher* $\boldsymbol{L}$*) as long as the product* $\boldsymbol{M}\cdot\boldsymbol{L}$ *does not decrease.*

Therefore, firms may be interested in increasing consumer heterogeneity even at the cost of selling to a smaller population of consumers. In fact, this is true for both firms, although not necessarily in the symmetric way implied by the specific assumptions made here.

Other Extensions

We have assumed that product qualities are exogenously given. We consider here the case in which firms strategically determine the environmental performance of their products. With costless environmental performance ($c = 0$), it is easy to see from equilibrium profits that both firms benefit from *maximum* differentiation. That is, the producer of the

standard product will make no effort to improve it, while the green firm will choose the best environmental performance it can. With costly environmental performance, things may be slightly different. For example, the aforementioned maximum quality differentiation result may not hold any more.[9] Note, then, that the condition under which the less environmentally aware firm prefers a less environmentally aware consumer population (Proposition 1) coincides with the condition which makes the less ecological firm earn higher profits by raising its product's quality. A simple way to extend the framework presented here would be to consider a maximum environmental performance $S_b^{\max} < S_a$ which could be reached by firm b at no extra cost. When the condition for profitability of improving the standard product holds (which, following Proposition 1, simultaneously implies profitability of a less environmentally aware market for the less ecological firm), the less ecological firm will increase its product's environmental performance to $S_b^{\max} < S_a$, reducing the difference in the environmental performance of the two varieties. With a costly improvement by firm b, we obtain a similar result. In any case, there is always a critical value of L for the corresponding result in Proposition 1 to be qualitatively robust to the variation considered here.

We could also generalize the framework considering that the extra unit production cost is a continuous function of the quality improvement achieved by the green product. That is, $c = c(S_a)$. Furthermore, we will need that $c(\cdot)$ is increasing in S_a and twice differentiable, with $c'' > 0$. Assume that the green firm decides its product's environmental performance in a stage preceding the price-setting stage of the game, from firm a's equilibrium profits in (8.1), we get: $H_a^e = d \cdot \frac{(2 \cdot L \cdot S_a - c(S_a))^2}{9S_a}$ which should be maximized at the optimum environmental performance improvement S_a^0, considering that product b's quality remains constant. The first order condition for this maximization problem gives: $S_a^0 = \frac{c}{2 \cdot (c' - L)}$, which can be shown to satisfy the second order condition if $c'' > -\frac{c' - L}{c}$. We should observe, then, that S_a^0 is positive as long as $L < c'$. In that case, the second order condition is always satisfied for positive values of c'' (and for some negative values of it). At the same time, firm's profits will be positive as long as $L > c'/2$ (from substitution of S_a^0 in Equation (8)). Finally, the less ecological product's manufacturer will fear the entry of more environmentally aware consumers if $L < 2c'/3$ (substituting S_a^0 in the second condition provided by Proposition 1). That is, for $c'/2 < L < 2c'/3$, the more ecological of the two firm would have incentives to improve its product with respect to its competitor's variety by S_a^0 and the less ecological one would fear the entry of more environmentally aware consumers, whereas, for $2c'/3 < L < c'$, the contrary will be true. An intuitively expected feature of the set-up is that the environmentally aware firms would never fear selling to a population of more environmentally aware consumers.[10]

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[9] In a framework in which both firms are allowed to choose qualities, Shaked and Sutton (1982) show this property of quality choice. Motta (1993) provides different cost conditions (quality may affect variable or fixed costs) under which less than maximum differentiation occurs in equilibrium.

[10] A simple version of this model could be: $c(S_a) = k \cdot S_a + g \cdot S_a^2$, for which the high quality firm's equilibrium profit has a unique (the second order condition, $4L - 2k > 3S_a g$, with $g > 0$, is satisfied simultaneously with the condition for a positive S_a^0) maximum at $S_a^0 = (2L - k)/3g$. In

We may also relax the assumption of the exogenously given asymmetry which assigns firms' roles as green and conventional. Note that, if $(2 \cdot L \cdot S_a - c) > (L \cdot S_a + c) \Rightarrow L > (2c/S_a)$, in our model (see expressions in (8)), the green manufacturer earns higher profit than his competitor does. With simultaneous choice of roles, firms will produce, in equilibrium (although this asymmetry may require some co-ordination mechanism), the less and the more ecological product in order to avoid a situation in which they produce identical varieties yielding zero profits. If one of the two firms acts first and chooses to produce the ecological product, then, from the aforementioned condition we can rule out the possibility of a less ecological firm fearing WTP changes of the second type. Otherwise, if the first firm to choose produces the less ecological variety, both cases implied in Proposition 1 are likely to hold.

CONCLUSIONS

We have shown that increasing the consumers' WTP for green products is far from a trivial equivalent to "throwing money into the market", especially, when such increases affect the heterogeneity of the population. The novelty of our findings is that socially undesirable increases in consumers' ecological awareness and the resulting conflict between private and social interests are shown to exist in the absence of consumer misperceptions or discontinuous changes in market structure.

Our framework is appropriate for assessing, in terms of private profitability and social welfare, the effects of exogenous factors which are perceived in different ways by consumers with different attitudes towards green products. A rather generic result concerns the fact that, in most cases, changes in consumers' WTP that are privately profitable are not the most desirable in terms of social welfare. In fact, it is easier to obtain interest compatibility between the two competitors than compatibility between one of the firms' profitability and enhancement of social welfare. An apparently counterintuitive result emerging from the similarity between consumer heterogeneity and product differentiation is that the less ecological manufacturer may find it profitable to sell to a more environmentally aware consumer population. Therefore, less environmentally aware firms are also likely to benefit from increasing consumer heterogeneity, rather than — as it could have been thought — from decreasing the consumer's WTP for ecological products.

Although we would not like to exaggerate the possibilities of state intervention in such detailed qualitative aspects of social trends and consumer-specific campaigns, it should be clear that any means of providing the consumer with more information on the environmental performance of the product they consume should be challenged against our main finding: in most cases, firm strategies would favor socially undesirable campaigns. An immediate policy implication of our main result is that governments should

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this example, the condition for positive profits to both firms becomes: $L > k/2$ and the condition in Proposition 1: $L > 2k$. Finally, the high quality firm will always find markets with more quality conscious consumers more profitable: $\frac{\partial H_a^e}{\partial L}\Big|_{M=\text{Cons.}} > 0 \Leftrightarrow \frac{4(k+4L)(k-2L)^2}{243gL^2} > 0$.

be favorable towards awareness-enhancing campaigns targeted towards the least ecologically conscious consumers. On the contrary, private campaigns targeted towards the most ecologically aware consumers should be seen as mere competition-relaxing devices. The widespread optimism inspired by the worldwide tendency of consumers to increasingly favor ecological products is justified only in the presence of simultaneous decreases in consumer heterogeneity.

The scope of our approach is limited to demonstrating the existence of parameter configurations under which some apparently plausible results do not hold, like for example the global desirability of increasing the consumer's ecological awareness, or the compatibility between a green firm's profitability and maximization of social welfare. In order to achieve our goal, we have used a very stylized model of duopolistic vertical differentiation, whose properties may not carry over intact to other, more general market settings. The robustness of our results with respect to further generalizations apart from the ones considered here and the numerous applications of this very simple framework to study other issues related with changing the consumers' attitude towards environmental performance, leave a lot of space for future research.

APPENDIX

Proof of Proposition 1. The proof follows the requirement that equilibrium quantities in Equation (7) are positive, implying inequalities: (i) $(2n - m) \cdot S_a - c > 0$ and (ii) $c - (2m - n) \cdot S_a > 0$. Condition (i) can be re-written -substituting $2n$ with $2(m + L)$, as: $(m + 2L) \cdot S_a - c > 0$. This implies that the first of the four expressions in (9.1) is positive. In a similar way, we obtain that the sign of the second expression is always negative, given that condition (ii) can be written — substituting n with $m + L$ — as: $(m - L) \cdot S_a - c < 0$. Finally, given the unambiguous signs of these two expressions, the sign of the third and fourth expressions in (9.1) will depend on the signs of the remaining brackets appearing on each one of the corresponding numerators. Thus, the third expression will be positive as long as $(m - 2L)S_a - c < 0$, which follows from $(m - L)S_a - c < 0$ (already shown above). The fourth expression's sign will be the opposite of the sign of $(m + L)S_a - c$, which can also be written as $n \cdot S_a - c$, as stated in the proposition. Inspection of signs in (9.2) requires (given condition i) observing that the sign of the first expression is positive if the first term in bracket on the numerator is negative (as stated in the proposition). Finally, the use of the second condition (ii) implies that the second term in brackets on the numerator is positive. Given that due to: (i), $c - (2n - m)S_a < 0 \Rightarrow c - (2n - m)S_a - L \cdot S_a < 0$, the second term in brackets is negative, implying $c - (3n - 2m)S_a < 0$, corresponding to an unambiguously negative sign of the second expression as needed for the proof of the proposition. ■

Proof of Proposition 2. Treating the product $M \cdot R$ as a constant, we obtain:

$$\frac{\partial SW}{\partial m} = \frac{M}{9L} \cdot (7L + 3 - 5(c - m)) \tag{A.1}$$

$$\frac{\partial SW}{\partial L} = \frac{M}{18L^2} \cdot (8L^2 + 6(c-m) - 5(c-m)^2) \tag{A.2}$$

Also,

$$\frac{\partial^2 SW}{\partial m^2} = \frac{5M}{9L} > 0 \tag{A.3}$$

$$\frac{\partial^2 SW}{\partial L^2} = \frac{M}{9L^3} \cdot (c-m) \cdot (5(c-m) - 6) > 0 \tag{A.4}$$

provided that $5 \cdot (c-m) > 6$. The roots of the equations $\frac{\partial SW}{\partial m} = 0$, $\frac{\partial SW}{\partial L} = 0$ are, respectively, $m^* = \frac{5c-7L-3}{5}$ (which is positive if $5c > 7L+3$), and $L* = \sqrt{\frac{(c-m)[5(c-m)-6]}{8}}$ (which corresponds to a real number as long as the content of the square root is positive, guaranteed, among other, by $c > m$ and $[5(c-m)] > 6$). The expressions of the second derivatives in (A.3) and (A.4) indicate that m^* and L^*, correspond to local *minima* of equilibrium social welfare. In case m^*, L^* do not fall within the support of the model, social welfare is unambiguously positively affected by changes of the first two types. Regarding the welfare effects of the third type of changes, we follow the methodology adopted in the previous section, expressing social welfare in terms of m and n. Given the limited insights which can be drawn from the resulting expressions, rather than re-writing SW in terms of m and n, we will focus on the derivatives:

$$\frac{\partial SW}{\partial m} = \frac{M \cdot \Omega}{18(n-m)^2} \tag{A.5}$$

in which, for simplicity, we substituted $\Omega = 6n^2 - 6c + 5c^2 + m^2 + 6n - 10cn - 2mn$, and

$$\frac{\partial^2 SW}{\partial m^2} = \frac{M(n-c)(6-5(n-c))}{9(n-m)^3} > 0 \tag{A.6}$$

if $5 \cdot (n-c) < 6$. This condition is compatible with the necessary condition for inequality (A.4) to hold, if $c > (n-m)/2$, which implies a relatively low heterogeneity compared to the extra unit production costs to be justified. However, Equations (A.5) and (A.6) imply that SW is a strictly increasing function of m, taking positive values for all non-negative values of the parameter (a more detailed proof is available from the authors). ■

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