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ABSTRACT: We analyse how market competition in a vertically differentiated polluting industry is affected by product variants that comply at different levels with "green" social norms. A green consumption behavior is considered as a byword of good citizenship. Consumer preferences depend on a combination of hedonic quality and compliance with social norms. Assuming that the high hedonic quality variant complies less with these norms than the low hedonic quality variant, we characterize different equilibrium configurations which appear as a result of both the intensity of such norms and the country-specific income dispersion. Then, we focus on the role that institutions may have in using these norms to reduce pollution emissions.

JEL Codes: D62, L13, H13

Keywords: Hedonic quality, environmental quality, relative preferences, environmental campaign.

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To secure her daughter a position on her high school cheerleading team , Wanda Webb Holloway solicited a man to kill the mother of her daughter's chief rival, hoping that the mother's death would distract the rival from the competition.' In Japan, enough people work themselves to death that the culture has a name for this means of dying: karoshi. [...]." (McAdams, 1992, 2)

1 Introduction

There are many situations in which people not only pursue an absolute goal, but also a *relative position of superiority* among peers. Typically, this is obtained through *positional goods* which provide buyers with some social/psychological benefits beyond the material needs that products traditionally satisfy.[1] In this paper we focus on the positional content of environmentally friendly "green" goods. The awareness that consumption choices have a crucial impact on the ecosystem in which we live is increasing worldwide. This is obviously changing strategic competition between firms, given that consumers are more and more informed about the damages caused by "brown" polluting goods. In addition, the positional content of green products can be channeled by policy makers into public programs of environmental protection.

On these grounds, we develop a theoretical model that comprises four *main ingredients*. *First* of all, an environmentally friendly good can satisfy the consumers' desire to stand out as *good citizens*, therefore being considered as *socially worthy* (Ostrom, 2000). On the contrary, when buying "brown" (polluting) products, consumers may incur a social stigma as they fail to be responsible citizens: *green consumption is a byword for good citizenship, likewise brown purchases leads to a blameworthy social image.*[2] Clearly, the more significant the green nature of a product as compared with the alternatives, the more relevant the contribution to the environmental protection and, accordingly, the higher the social/psychological benefit for the green consumer. At the same time, the more polluting the product as compared with the green alternative, the stronger the social stigma. The environmental quality gap between variants is a measure of the positive (or negative) contribution to environmental protection and thus the product's position along an *environmental quality ladder* reflects the individual's relative position on the *social ladder*.

[1] This behavior has been well described since Veblen (1899) by the theory of conspicuous consumption, in which consumer's utility (or status) depends at least partially on the comparison of one's own consumption and good's quality to that of others. Under conspicuous consumption, buyers are willing to pay a higher price for a functionally equivalent good in order to reveal their wealth, their social status or other specific characteristics. See Bagwell and Bernheim (1996) and Bowles and Park (2005) for recent contributions.

[2] Notice that this positional content has no direct relationship with the current regulation adopted in a specific country. Take as an example the automotive emissions standards set by the European Union. Two types of car can meet the requirements, while having different emissions levels. From the EU viewpoint, both of them are *sufficiently* green and therefore do not incur any restriction to circulation. However, from the consumers' viewpoint, the less pollutant the car, the more significant the contribution to the environment and therefore the better the social image.

If this is the case, why are brown products still so popular? Usually brown goods have higher levels of performance than green alternatives (Carrigan and Attalla, 2001; Gupta and Ogden 2009, Weatherell *et al.*, 2003). For example, conventional internal combustion engine vehicles, although dominated by green alternatives in terms of polluting emissions, are still superior to electric or hybrid vehicles based on pure performance. Accordingly, the ranking of brown *versus* green goods along the quality ladder, and thus the resulting consumption behavior, mainly depends on the importance that people attach to the environmentally friendly nature of the product as compared to some other attributes.[3] Thus, the existence of a *conflict between* the social component of consumption and the individual-rationality-based motive constitutes the *second* ingredient of the analysis.

Third, the solution to this conflict seems to be related to the income-dispersion within a country (or region).[4] In countries where the per-capita income dispersion is rather significant (*i.e.* Portugal and Turkey), brown goods are still widespread. On the contrary, in countries with low per-capita income dispersion (*i.e.* France and North of Europe) green production is increasing. Take as an example the organic food industry; in the European Union, the largest markets are Germany and France, while the highest per capita consumption is in Switzerland and Denmark.[5]

Finally, in the past few years public authorities have further invested in campaigns to bring awareness to the broad public about the detrimental effects of bad consumption habits on the environment. Such campaigns constitute the fourth ingredient of our analysis. Many examples can be provided, such as "Generation Awake", created by the European Commission to inform citizens about the consequences that their consumption patterns have on natural resources, energy utilization, and waste recycling. It also includes a detailed consumption guide that draws attention to the environmental impact of various products and daily habits.[6] "Cambia la lampadina" (Change the Light Bulb) was launched in Italy in 2010 and developed by the Ministry of the Environment, comparing consumption of incandescent light bulbs versus low-energy consumption light bulbs.[7] In the US, the National Environmental Policy Act (NEPA) requires an environmental impact statement (EIS) that describes the positive and negative environmental effects of each proposed action. It also provides information on potential alternatives, thus helping policy-makers when deciding whether or not to implement a specific action that has an impact on the human and natural environment.

As for the automotive industry, there are many examples of informative policies on CO_2 emis-

[3] In spite of the neoclassical approach to utility-maximization, there can be a trade-off between utility derived from preferred characteristics of a product and the social pressure to buy "green". "If a consumer buys a product which lacks any environmental friendly characteristics, he might have a bad conscience because environmental awareness is expected from him. His environmental attitude is influenced by friends, parents, partners, or by the media..."(Conrad 2, 2005).

[4] On the relationship between inequality and green consumerims, see first the seminal paper by Boyce (1994), and then Magnani (2000), Vona and Patriarca (2001) and Pfaaf *et al.* (2004), *inter alia.*

[5] Source: FiBL-AMI-OrganicDataNetwork survey 2014

[6] See http://www.generationawake.eu/en/ for details.

[7] See the website http://www.minambiente.it/pagina/campagne-ed-iniziative for details on other Italian campaigns and initiatives.

sions of various vehicles. In the EU, for example, we can mention the Italian guidelines on CO_2 emission savings, which ranks vehicles according to their environmental impact,[8] and the the "Drive Green" campaign launched in 2011 by the Danish Transport Authority to encourage Danes to adopt a green (and energy efficient) driving attitude. In the US the EPA Smart Way program compares environmental performance of different vehicles.[9] Likewise, in Australia the Green Vehicle Guide helps drivers by rating new Australian vehicles on the basis of greenhouse and air pollution emissions.[10] The rating is calculated using data provided by manufacturers from specific tests following the Australian standards.[11]

The basic framework

In order to formalize the above evoked ingredients, we define a market consisting of two firms providing vertically differentiated goods to a population of consumers. The functionality of a product determines its hedonic quality so that the high quality variant is characterized by a better performance. Nonetheless, this variant is more polluting than the low quality alternative. We assume that the utility deriving from consuming a product variant depends not only on its hedonic quality but also on the *environmental quality gap* between this variant and the other available in the market.[12] While this assumption allows us to capture the social role of consumption in enhancing environment protection, it makes the choice between the two variants far from being evident. Indeed, increasing the hedonic quality of a product does not suffice *a priori* to increase its demand given that a better performance may imply a higher level of pollution. We develop the equilibrium analysis while taking into account some specific features of the market. In particular, we consider first *(i)* countries (or regions) with low-income dispersion and then *(ii)* countries with high-income dispersion.[13] From a theoretical viewpoint, this choice allows us to specify the properties of the equilibria for the whole range of parameter values. Furthermore, the analysis contributes to the open debate on the relation between income dispersion and pollution. In a recent IMF Staff Discussion Note a multi-decade cross-country relationship between inequality and the fragility of economic growth was widely discussed.

[8]The Italian guidelines are a joint effort between the Ministry of Transportation, the Ministry of Economic Development and the Ministry of Environment. For further details visit www.mit.gov.it/mit/site.php?p=cm&o=vd&id=2724.

[9]Visit www.epa.gov/smartway/basic-info/index.htm for further details. The Environmental Protection Agency (EPA) is an agency of the U.S. federal government which was created for the purpose of protecting human health and the environment by writing and enforcing regulations based on laws passed by Congress.

[10]Visit http://www.greenvehicleguide.gov.au/GVGPublicUI/home.aspx

[11]Other examples include campaign in favor of alternative ways of transportation. The "European Mobility Week", an annual campaign on sustainable urban mobility, encourages local authorities to promote sustainable transport measures as alternatives to cars. Similarly, "Bike to Work Day" is an annual event held on various days across the US and Canada that promotes the bicycle as an option for commuting to work.

[12]In his pioneristic paper, Akerlof (1997) stated that the satisfaction of a consumer increases with the difference between the personal status and others' status. Later, Alexopoulos and Sapp (2006) and Reichmann (2006) analyze relative preferences from the point of view of firms. These preferences are also labeled "*other-regarding preferences*".

[13]By keeping as constant the consumers' distribution density, the heterogeneity among consumers can be used as a proxy for the income dispersion in a country and this enables us to consider how the equilibrium configuration changes with this dispersion (see Gabszewicz and Thisse, 1979).

The authors argue that:

> "inequality can undermine progress in health and education, cause investment-reducing political and economic instability, and undercut the social consensus required to adjust in the face of shocks, and thus that it tends to reduce the pace and durability of growth." (Berg *et al.*, 2014, 4)

Inequality between countries, and more importantly between regions within a country, is therefore still very significant. In this paper we show that income inequality (between the rich and poor in individual countries, or between countries) can play a crucial role also in magnifying the pollution phenomenon. In particular, we demonstrate that, whenever consumption is also driven by positional motives, the traditional assumption of rationality-based behavior can constitute an overly drastic simplification with possible misleading implications on the equilibrium analysis and social welfare. Indeed, we identify situations in which the producer of the low hedonic quality good can quote a higher price than the rival because of the green nature of its product. At this duopoly equilibrium a *price switch* takes place, and this is new in comparison with the typical finding that the high quality good is sold at a higher price than the low quality variant. Furthermore, we find that a *market-monopolization effect* takes place whenever the intensity of relative preferences is sufficiently high; only the green firm can stay active in the market, the "dirty" competitor being pushed off the market. Moreover, at this monopoly equilibrium configuration, for extremely high intensity of relative preferences, the green monopolist extends the market coverage farther than what is typically observed in a vertically differentiated setting, thereby inducing a *market-coverage effect*. As both the price switch and the market-monopolization effects mainly depend on income dispersion, the competition between green and brown competitors is largely shaped by the level of income inequality worldwide.

Finally, we draw policy considerations and analyse whether institutions can channel these preferences into green (and possibly welfare improving) production "rather than into pointless display".[14] To this end, we assume that the government can endorse a costly environmental campaign aiming at increasing consumers' environmental awareness. We find that amplifying the role of social norms through the campaign can be welfare improving, and that the optimal investment in the campaign is country-specific as it mainly depends on the income-dispersion. Two features of this campaign are remarkable, Firstly, it may contribute to solve the trade-off between environmental protection and competition improvement. Traditional environmental policy tools like taxation and emissions standards are usually detrimental to consumers as they bring about a price increase.[15] Our model

[14] See P. Krugman, "The Mercedes menace", USA Today, Jan.13, 1998.

[15] Controversies exist between those arguing that environmental policy is likely to stifle competitiveness by imposing additional burdens on firms' production costs, and those claiming that new environmental technologies can prompt competitiveness among firms (See OECD Environment Working Papers, No. 13, 2010). Moreover, it has been argued

suggests a way out from such controversy, as reinforcing the social/psychological component of consumption may allow a society to combine output expansion with pollution reduction. Secondly, it avoids the so-called *carbon leakage effect* that takes place when a tighter environmental regulation in one country determines a higher level of pollution in countries that are more permissive (see Sanna-Randaccio and Sestini, 2012, for a recent discussion).[16] In our setting, when the green firm monopolizes the market, relocating production abroad impedes the brown competitor to re-enter the home market via export.

Related Literature

Recently, increasing attention has been devoted to the impact of environmental awareness on market equilibrium (Conrad 2005, Eriksson 2004, García-Gallego and Georgantzís 2009, Moraga-Gonzalez and Padro-Fumero 2002, Nyborg *et al.* 2006, Rodriguez-Ibeas 2007, Ben Elhadj and Tarola 2014, *inter alia*). However, to the best of our knowledge, we are the first to combine in a unified setting of vertical differentiation the notion of relative preferences and the possibility of a conflict between traditional hedonic qualities and newly established environmental qualities. In this perspective, we complement the paper by Conrad (2005) and that by Ben Elhadj and Tarola (2014). The former considers the trade-off between the utility derived from the preferred characteristics of a product and the moral behavior of buying "green" in a horizontal differentiation setting. The latter is based instead on a vertically differentiated setting where relative preferences are explicitly taken into account, as people seek a *relative* position among peers and buy products also for their social value.

More specifically, Conrad (2005) analyzes a two stage game where firms define the environmental characteristic of the products at the first stage, thereby competing in price at the second stage.[17] We share the view that environmental concern can modify traditional consumers' preferences and, accordingly, it must be incorporated directly into the utility function. Nevertheless, we depart from his model as our analysis is conceived in a vertically differentiated setting. We embrace the view that the environmental quality is perceived as a positive characteristic of the product, and consumers are willing to pay a higher price for a green good (Farhar and Houston 1996, Wasik 1996, Lombardini-

that excessive competition may conflict with environmental protection. The liberalization/deregulation of air transport system, for example, reduced overall fares but increased pollution: consumers pay a cheaper price for their air transport, but suffer from the negative externality stemming from an increase of polluting emissions, especially in airport hinterlands (see the Environmental Change Institute Report, 2006, and Graham 2008, Ch. 8, *inter alia*).

[16]Typically, this is observed whenever firms relocate their (polluting) production activities abroad in response to environmental measures unilaterally adopted by their home governments. They keep serving their original market via export, thus not reducing significantly output provision. However, this can be detrimental in terms of global pollution if the increase in pollution abroad overcompensates the reduction of pollution at home.

[17]More recently, Coad *et al.* (2009) consider the processes of adoption of pro-environmental innovations by individual consumers. They point out that as environmental protection is a public good, not all agents can be willing to preserve environment. In this view, they wonder whether the Government policy may thus intervene to sustain adoption of environmental innovations such as environmentally-friendly cars. Although they are mainly concerned with the notion of public good, their discussion on intrinsic motivation and environmental morale provides useful insights to our analysis.

Riipinen 2005, and García-Gallego and Georgantzís, 2009). Finally, far from Conrad (2005), we assume that both the social benefit and the social stigma attached to buyers increase with the environmental quality gap between variants.[18]

Ben Elhadj and Tarola (2014) introduce relative preferences in a model of vertical differentiation, and we follow such an approach. As in their paper, we also consider that the relative position of a consumer in the social ladder depends on the relative position of the product variant that she buys along the quality ladder. Nevertheless, they limit their attention to the case in which a variant is simultaneously of higher hedonic quality and more environmentally friendly than the alternative. Accordingly, it never arises a conflict for the consumer between the pure performance of a product and the social image that can be associated to its consumption. We complement their analysis by introducing such a conflict into the utility function.

Moreover, departing from both Conrad (2005) and Ben Elhadj and Tarola (2014), we also analyze the role of institutions in affecting consumers' decisions through educational programs that provide information about the impact of their choices on the environment. By introducing this policy instrument, we broaden the scope for government intervention against global pollution. In this nature, our paper relates with a recent stream of literature supporting environmental/informative campaigns as a policy instrument to supplement and/or substitute traditional environmental policies such as taxation and subsidies.[19] In Sartzetakis *et al.* (2012) the information campaign is an efficient complementary policy because it reduces the asymmetry of information between consumers and manufacturers. In Mantovani and Vergari (2013), the effectiveness of the two policy instruments, environmental campaign *versus* taxation, crucially depends on consumers' environmental awareness. García-Gallego and Georgantzís (2009 and 2011) argue that increasing consumers' ecological awareness may be socially undesirable. In their first paper, this is due to possible changes in market structure. In their second paper, it depends on the target of the campaign; increasing the willingness to pay of the most environmentally conscious consumers is privately profitable (but socially unprofitable), whereas increasing the willingness to pay of the least environmentally conscious consumers is socially profitable (but privately unprofitable). They conclude that the state cannot rely on private campaigns.[20] We contribute to the above literature by showing that environmental campaigns can improve social welfare when the realistic assumption of a conflict in consumption behavior is introduced in the model.

Our paper is also related to two important conflicts of policy. The first one concerns an "internal" policy conflict between environmental authorities (aiming at reducing pollution) and competition authorities (aiming at fostering competition), given that one of the side effects of traditional envi-

[18] In Section 3, we will discuss at lenght how our utility function differs from that modeled by Conrad (2005).

[19] See Moraga-Gonzales and Padron-Fumero (2002), Lombardini-Riipinen (2005) and Deltas *et al.* (2013) for contributions on optimal tax policy with environmental quality.

[20] See also van der Made and Schoonbeek (2009) for the effects of an environmental campaign conducted by a private group.

ronmental measures is an output shrink. Many contributions study the design of optimal Pigouvian taxation which should induce firms to lower damaging emissions, both in monopoly and oligopoly settings (Karp and Livernois, 1994; Benchekroun and Long, 1998, 2002; Damania, 1996). Another stream of literature analyses the feasibility of tradeable pollution permits, which, however, may lead to the monopolization of the industry (Newbery, 1990; von der Fehr, 1993).[21] The second policy conflict is "external" and it refers to the risk that more stringent national mitigation measures put in place with the aim of reducing emissions in a country might lead domestic production shifting to other less regulated regions (the so called Pollution Havens) with an ambiguous effect on global pollution (*e.g.* Hoel 1991, Copeland and Taylor, 1994, 2003, Petrakis and Xepapadeas, 2003, Abe and Zhao, 2005; Di Maria *et al.*, 2008).

Finally, we also contribute to the literature on the relationship between income inequality and the development of green productions. The empirical evidence on this issue is not conclusive. The so-called environmental Kuznets curve hypothesis (Grossman and Krueger, 1995), according to which economic growth (which is in turn linked to income inequality) is coupled to reductions of per capita emissions above certain income levels, is still under debate (see *e.g.* Harbaugh *et al.*, 2002). Not even clear conclusions have been reached by theoretical contributions in this field. Some works point out that growth determines environmental deterioration (Roca, 2003; Gawande *et al.*, 2001; Kempf and Rossignol, 2007), while others find that inequality can enhance green consumption as high-income consumers are usually willing to buy environmentally friendly product (Heerink *et al.*, 2001). By assuming a conflict in consumers' preferences, we can consider to what extent income dispersion can play a role in enhancing green productions depending on the environmental awareness of consumers and their willingness to pay for the hedonic quality of products, thereby reaching some country-specific conclusions.

The structure of the paper is as follows. In Section 2 we set up the model. In Section 3 we develop the country-specific equilibrium analysis and compare the results for countries (regions) characterized by low income dispersion versus countries characterized by high income dispersion. In Section 4 we provide the welfare analysis. Section 5 concludes.

2 The Model

Consider a vertically differentiated market with two variants of the same good. Similarly to the models of vertical differentiation (Mussa and Rosen 1978), we state that the performance of the variant i, with $i = L, H$, determines its *intrinsic* or *hedonic quality* q_i. Accordingly, $q_H > q_L$: variant H has a higher intrinsic quality than variant L. Nevertheless, as it generates polluting emissions per unit of production at some level $e_H = \phi q_H$, variant H represents the brown good. Conversely,

[21] See also Lambertini (2013, especially Chh. 2 and 6), for a comprehensive survey.

variant L is considered as green because its emissions e_L are very low, namely $e_L = \phi q_L < e_H$. The *environmental quality* of L is then higher than that of H.

There is a continuum of consumers indexed by θ and uniformly distributed in the interval $[0, b]$ with density $\frac{1}{b}$. Keeping the traditional interpretation from vertical differentiation models, parameter θ is proportional to the willingness to pay (henceforth WTP) for quality, so that b denotes the maximal WTP among consumers.[22] Notice also that, the higher is b, the higher is the heterogeneity among consumers captured by the dispersion of the willingness to pay. Each consumer can either buy one unit of good H or one unit of good L or none at all.

Whenever a vertically differentiated setting is used to analyze an environmental problem, it is generally assumed that otherwise identical products differ in their emissions so that the environmental quality represents the only source of differentiation (Moraga-Gonzales and Fumero 2002, Lombardini-Riipinen 2005, and García-Gallego and Georgantzís 2009, Ben Elhadj and Tarola, 2014). Here we assume that there are two sources of differentiation: the hedonic quality q_i and the environmental quality e_i, and these two forces are in conflict with each other.[23] Formally, the indirect utility of consumer type θ writes as:

$$U(\theta) = \begin{cases} \theta q_H - p_H - \gamma (e_H - e_L), \text{ if she buys the high quality good,} \\ \theta q_L - p_L + \gamma (e_H - e_L), \text{ if she buys the low quality good,} \\ 0, \text{ if she refrains from buying.} \end{cases}$$

We add to the traditional component of the indirect utility function ($\theta q_i - p_i$) a further ingredient, namely $\gamma (e_H - e_L)$ with $i \neq j$, such that the satisfaction of buying a product variant can be either amplified or decreased by the environmental characteristics of variant i as compared with j. Therefore, it is not the level of emissions *per se* to determine the utility of consuming a variant. Rather, as both the green and the brown variant are intended here as positional goods, it is the *relative* pollution coming from them - captured by the term $|\gamma (e_H - e_L)|$ - to affect consumers' utility.[24] Parameter $\gamma \geq 0$ measures therefore the intensity of the relative dimension of consumption;[25] the higher the value of γ, the stronger the relative (or social) preferences with respect to the hedonic ones.[26] For the sake of simplicity and without any loss of generality, we can assume that $\phi = 1$, so that $(e_H - e_L) = (q_H - q_L)$.[27]

From the above formulation of the utility function, the consumer indifferent between buying the

[22] Under this assumption on density, the population of consumers is always constant. See Garcia-Gallego and Georgantzis (2009).

[23] It is worth noting that, from a social welfare viewpoint, the relative environmental quality of a variant does not play any role, being rather the absolute level of emissions e_L and e_H, the reference point of a social planner.

[24] See Ben Elhadi *et al.* (2014) for an indepth discussion on this approach.

[25] In our work, we use the terms *social* and *relative* as synonymous given that they both indicate that consumption has a social dimension. Likewise, the resulting satisfaction also depends on the characteristics of society.

[26] The extreme case $\gamma = 0$ reduces the model to the traditional vertical differentiation framework with hedonic preferences as unique drivers for consumption.

[27] We could consider a generic $\phi > 0$ without normalizing ϕ to 1. However, this would not bring any further insight to the model while making the welfare analysis by far more cumbersome.

low quality good and not buying at all is:

$$\theta_L = \gamma + \frac{p_L - \gamma q_H}{q_L} = \frac{p_L - \gamma(q_H - q_L)}{q_L}. \tag{1}$$

The consumer indifferent between buying the low quality good and the high quality good is:

$$\theta_H = 2\gamma + \frac{p_H - p_L}{q_H - q_L} = \frac{p_H - p_L + 2\gamma\,(q_H - q_L)}{q_H - q_L}. \tag{2}$$

Note that, at given prices, the market share of L increases in γ. Indeed, *ceteris paribus*, θ_L shifts leftward in comparison with its position in the traditional setting of vertical differentiation. Typically, in a vertically differentiated model, whenever the lowest WTP is 0, the market can never be covered.[28] Here, on the contrary, consumer of type $\theta = 0$ can have a positive utility from buying L if $\gamma\,(q_H - q_L) > p_L$. Thus, it can be profitable for the green producer to cover the market at equilibrium, serving also the consumer with the lowest WTP.

We assume that profit functions of firms H and L write, respectively:

$$\pi_H = x_H \cdot p_H, \tag{3}$$

$$\pi_L = (p_L - c)\, x_L. \tag{4}$$

with x_i denoting the demand faced by firm i, and $c > 0$ is the cost per unit of green production. In the above formulation, it is implicitly stated that production costs for firms only come from producing an environmentally friendly good. Otherwise, one could imagine that there exists a cost function $c_i = h_i + E_i$ where h_i denotes the hedonic-quality specific cost borne by firm i, with $h_H > h_L$ and E_i the environmental quality specific cost, with $E_H < E_L$.[29] Since it is reasonable that $h_H > h_L$ always holds, the only way to get $c_H < c_L$ is to assume that $(E_L - E_H) > (h_H - h_L)$. Without any loss of generality, we can write $c_L > c_H = 0$.[30]

Before going through the possible equilibria, we make the following assumption that holds throughout the paper:

Assumption 1

$$b \geq \underline{b} \equiv \frac{c\,(2q_H - q_L)}{q_L\,(q_H - q_L)}.$$

[28] Since firms are not allowed to price discriminate, they should quote a price equal to zero to meet the marginal consumer $\theta = 0$, as this latter would get a non positive utility from consuming at some positive price. Accordingly, either they would get zero market share at a positive price, or a positive market share at zero price. In either case, the equilibrium profits would be zero.

[29] The case when $c_H > c_L$ has been largely treated in the literature on vertical differentiation (Cremer and Thisse 1994). Thus, we can disregard it.

[30] One may wonder why we do not introduce some fixed costs to capture the role of green technologies in production. Admittedly, when the quality is mainly related to investments in new technologies or in R&D, the assumption of fixed quality-specific costs can be reasonable. Nevertheless, a fixed cost does not affect the price game as it does not alter firms' best reply functions.

Assumption 1 ensures a sufficiently large consumers' heterogeneity and it will help reducing the conditions that we have to take into account for an equilibrium to exist.[31]

We develop the analysis considering in turn two different scenarios, based on the values of the parameter b. To this aim, we consider the following threshold value:[32]

$$\widetilde{b} \equiv \frac{cq_H}{(q_H - q_L)^2}. \tag{5}$$

In the next Section we first consider the case in which $b < \tilde{b}$. Then, we move to the case in which $b \geqslant \tilde{b}$. Since the seminal paper on vertical differentiation by Gabszewicz and Thisse (1979), the parameter b represents the willingness to pay for a product variant and it is linked to net income; consumers with the highest willingness to pay are those with the highest per-capita income. Clearly, the higher is b, the higher is the per-capita income-dispersion in a country (or region).[33] Borrowing this interpretation, we can develop a market-specific analysis thereby identifying how this market feature affects the equilibrium configuration. In particular, when assuming that $b < \tilde{b}$, one can imagine that the equilibrium analysis is set for *countries (*or *regions) with low-income dispersion.* On the other hand, when $b \geqslant \tilde{b}$ the analysis is performed for *countries with high-income dispersion.*

3 The equilibrium analysis

We will show in the following that different market equilibrium configurations may arise, depending on parameters' values. In order to solve the model, we compute the price equilibrium candidates corresponding to each market configuration and provide the parameter intervals for which candidates yield the corresponding market outcomes.[34]

3.1 Low-income dispersion

Let us first consider the case where $b \in [\underline{b}, \tilde{b}]$, thereby focusing on low- *per capita* income dispersion. Typically, in a vertically differentiated setting, absent production costs, there is always room for two firms if the market is not a *natural duopoly.*[35] Furthermore, when the lowest WTP in the market is equal to zero, firms never find it profitable to cover the market. Accordingly, the starting point of our analysis is that both firms are active and the market is uncovered. Therefore, demands are

[31] Under such condition, the price charged by firm L at equilibrium is always higher than the marginal cost, as we will show in the next section. Removing such an assumption does not change the main results of our paper. Additional calculations are available upon request.

[32] This value comes from the ranking of the relevant $\gamma-$thresholds, as we will show in the next section.

[33] Technically, the dispersion is measured by the distance between the highest and the lowest WTP that in this case is b (given that the lower bound in our setting is equal to zero).

[34] This is standard in models of vertical differentation. See Wauthy (1996) for more details.

[35] The upper bound to the number of firms which can coexist at equilibrium with positive market share and positive equilibrium prices has nothing to do with costs and only depends on pattern of tastes and willingness to pay distribution. In particular, given a population of consumers, identified by the parameter $\theta \in [\alpha, \beta]$, $0 \leq \alpha < \beta$ the upper bound to the number of firms is 2 so that the market is a natural duopoly iff $\frac{\alpha}{\beta} \in \left[\frac{1}{4}, \frac{1}{2}\right]$.

defined as $x_L = \theta_H - \theta_L$ and $x_H = b - \theta_H$. Profit functions for firm H and firm L are given by:

$$\pi_H = x_H \cdot p_H, \tag{6}$$

$$\pi_L = (p_L - c)\, x_L, \tag{7}$$

and the pair of candidate equilibrium prices can be easily obtained:

$$p_L^* = \frac{2cq_H + (q_H - q_L)(2\gamma q_H + bq_L)}{4q_H - q_L}, \tag{8}$$

$$p_H^* = \frac{cq_H + (q_H - q_L)[2bq_H - \gamma(3q_H - q_L)]}{4q_H - q_L}. \tag{9}$$

Formally, for this candidate to be an equilibrium, we need to verify that both prices are positive and that p_L be higher than marginal cost, namely $p_H^* > 0$ and $p_L^* > c$. Moreover, we have to demonstrate that the market is uncovered, and that both goods have positive demands, *i.e.* $0 < \theta_L < \theta_H < b$. First, Assumption 1 suffices to guarantee that $p_L^* > c$, as it can be easily demonstrated. Second, in $b \in [\underline{b}, \tilde{b}]$, both firms are active in the market only if the intensity of relative preferences γ is sufficiently weak. In particular, by plugging (8) and (9) into (1) and (2), we obtain:

$$\theta_H^* < b \iff \gamma < \overline{\gamma} \equiv \frac{q_H[c + 2b(q_H - q_L)]}{3q_H^2 - 4q_H q_L + q_L^2}, \tag{10}$$

$$\theta_L^* > 0 \iff \gamma < \widehat{\gamma} \equiv \frac{2cq_H + b\,(q_H - q_L)\, q_L}{2q_H^2 - 3q_H q_L + q_L^2}, \tag{11}$$

where the precise values of θ_L^* and θ_H^* are reported in the Appendix. Notice that:

$$\widehat{\gamma} > \overline{\gamma} \iff b < \widetilde{b}.$$

Then, it is immediate to formally prove that:

Lemma 1 *In the range where $b \in [\underline{b}, \widetilde{b}]$, the conditions $slp_H^* > 0$, $p_L^* > c$, and $0 < \theta_L^* < \theta_H^* < b$ simultaneously hold whenever $\gamma < \overline{\gamma}$.*

Proof. See the Appendix. ■

Hence, when $\gamma < \overline{\gamma}$ (where $\overline{\gamma} < \widehat{\gamma}$), the existence of relative preferences in $b \in [\underline{b}, \widetilde{b}]$ does not alter the market structure we are accustomed to in traditional vertically differentiated settings. In spite of the social component of consumption, both firms are active at equilibrium. However, notice that:

$$p_L^* \gtrless p_H^* \iff \gamma \gtrless \widetilde{\gamma} \equiv \frac{2bq_H^2 - 3bq_H q_L - cq_H + bq_L^2}{(q_H - q_L)(5q_H - q_L)}. \tag{12}$$

As $\widetilde{\gamma} \in (0, \overline{\gamma})$, then in $b \in [\underline{b}, \widetilde{b}]$ it may well happen that consumers value more the green nature of a product than its performance. In particular, this occurs in $\gamma \in (\widetilde{\gamma}, \overline{\gamma})$, where the equilibrium price of the low quality variant turns out to be higher than the high quality one, namely $p_L^* > p_H^*$. This

is referred to as a *price switch effect* and it represents one of the main novelties of our model in comparison to standard models of vertical differentiation.

It is worth noting that $\widetilde{\gamma}$ is increasing in b; the parametric region where the traditional price structure holds ($p_H^* > p_L^*$) is increasing in market heterogeneity, captured by b. The economic intuition underlying the relation between $\widetilde{\gamma}$ and b is as follows. On the one hand, the higher the b, the more significant are both consumers' heterogeneity and income dispersion, which in turn determines a lower degree of price competition between firms. Accordingly, when b increases, the equilibrium price set by both firms tend to rise. On the other hand, when γ increases, the relative environmental quality of each variant becomes more significant, thus the price for the green variant rises. To sum up, given b, for sufficiently high values of γ, consumers value the environmentally friendly nature of the product so much that they are even willing to pay a higher price for the green good, regardless of the hedonic quality gap between the two variants. On the contrary, given γ, for sufficiently high values of b, the hedonic quality of variant H is appreciated to the point that consumers are willing to pay a higher price in comparison to variant L, regardless of the environmental quality gap.

Next we consider the range of $\gamma-$parameters in which $\gamma \geq \overline{\gamma}$. While there was still room in the market for both producers for $\gamma < \overline{\gamma}$, given that $\theta_H^* < b$ (or $p_H^* > 0$) from (10), when $\gamma \geq \overline{\gamma}$, the high-quality firm is so negatively affected by its brown nature that it can no longer be active in the market, therefore $p_H^* = 0$. Notice that $\overline{\gamma}$ is increasing in b: the lower is b, the larger is the set of γ parameters in which the green producer becomes a monopolist. This confirms the interplay between parameters γ and b that we previously outlined. In this monopoly setting, the indifferent consumer θ_L is once again defined by (1). However, the demand for the good L is now given by $x_L = b - \max\left\{0, \theta_L^M\right\}$. From standard computations, we find that the equilibrium monopoly price is:[36]

$$p_L^M = \frac{1}{2}[c + \gamma\,(q_H - q_L) + bq_L], \tag{13}$$

where superscript M refers to the monopoly case. At this monopoly equilibrium, the market can either be uncovered (namely $0 < \theta_L^M < b$) or covered (namely $\theta_L^M < 0 < b$), depending on the intensity of γ. In particular:

Lemma 2 *In the range where $b \in [\underline{b}, \widetilde{b}]$, the condition $0 < \theta_L^M < b$ holds for any $\gamma \in (\overline{\gamma}, \gamma_M)$, where $\gamma_M \equiv \dfrac{c + bq_L}{q_H - q_L}$. On the contrary, $\theta_L^M \leq 0 < b$ holds whenever $\gamma \geq \gamma_M$.*

Proof. See the Appendix. ■

The economic intuition of the above lemma goes as follows. Whenever $\gamma \in (\overline{\gamma}, \gamma_M)$, then it is not profitable for the green producer to cover the market. Recall that at the equilibrium that arises in

[36] It is worth remarking that while the high quality firm is no longer active in the market, it continues to play a role. Indeed, the candidate equilibrium price p_L^M depends on the quality gap between variants $(q_H - q_L)$.

the traditional framework, the market, defined over the interval $[0, b]$, is always uncovered.[37] On the contrary, when $\gamma \geq \gamma_M$, the intensity of relative preferences is such that even the consumer with the lowest WTP is predisposed to pay a price that induces the low quality firm to cover the market.

The following Proposition summarizes the most important results for countries with low-income dispersion:

Proposition 1 *Under low-income dispersion, both firms are active whenever $\gamma < \overline{\gamma}$. At this duopoly equilibrium, the market is uncovered and in $\gamma \in [\widetilde{\gamma}, \overline{\gamma})$ equilibrium prices are such that $p_L^* > p_H^* > 0$. On the contrary, whenever $\gamma \geq \overline{\gamma}$, the high quality but brown firm can no longer stay active and the market is monopolized by the low quality but green rival. At this monopoly equilibrium, the low quality firm covers the market for any $\gamma \geq \gamma_M$, whereas for $\gamma \in [\overline{\gamma}, \gamma_M)$ the monopoly market is uncovered.*

Proof. It follows from Lemma 1 and Lemma 2, and the discussion thereafter. ■

For relatively low values of γ, whenever the "brown-penalty/ green-reward" is not very significant ($\gamma < \overline{\gamma}$), both firms are active and at the duopoly equilibrium the market is uncovered. Nevertheless, the existence of γ can determine a switch in the ranking of equilibrium prices, so that $p_L^* > p_H^*$ when $\gamma > \widetilde{\gamma}$.

For relatively high values of γ, namely whenever consumers feel the social responsibility to protect the environment ($\gamma > \overline{\gamma}$), a *market-monopolization effect* takes place so that only the green firm can stay active. Indeed, in this case, consumers value the green nature of the goods to such an extent that they are not willing to buy the brown product, whatever its performance (and thus its hedonic quality).

Also, when $\gamma \geq \gamma_M$, the green monopolist extends the market coverage farther than what is typically observed in a vertically differentiated setting, thereby inducing a *market-coverage effect*. On the one side, this can be *a priori* detrimental from a welfare viewpoint, as it reduces the number of variants in the market, thus possibly raising the equilibrium price of the remaining goods. On the other side, this can be welfare-enhancing as some consumers which traditionally refrain from buying are now willing to purchase.

3.2 High-income dispersion

Let us analyse now the alternative case with $b > \widetilde{b}$. First of all, simple algebra reveals that

$$\widehat{\gamma} < \widetilde{\gamma} \iff b > \widehat{b} \equiv \frac{3cq_H}{q_H^2 - 3q_H q_L + 2q_L^2},$$

with $\widehat{b} > \widetilde{b}$. Let us focus on the case in which consumers' heterogeneity is not very significant, namely $b \in (\widetilde{b}, \widehat{b}]$, so that $\widehat{\gamma} \geq \widetilde{\gamma}$. The analysis can be easily extended to the extreme case with very strong

[37] On one hand, the consumer of type $\theta = 0$ would always get a non-positive utility from buying either good at some positive equilibrium price. On the other hand, a firm would obtain non positive profits by selling its good at a nil price to meet the consumer $\theta = 0$ if price discrimination were not allowed.

heterogeneity ($b > \widehat{b}$) without changing the main qualitative results.[38] First, it is relatively easy to demonstrate that, when $\gamma \in (0, \widehat{\gamma}]$, the equilibrium is a duopoly with both firms active in an uncovered market. Moreover, in line with the result emerged in the previous section, we still find that, depending on whether $\gamma \lessgtr \widetilde{\gamma}$, a price switch can emerge at equilibrium. In particular, $p_L^* \geq p_H^*$ (resp. $p_L^* < p_H^*$) when $\gamma \geq \widetilde{\gamma}$ (resp. $\gamma < \widetilde{\gamma}$), with the price gap $(p_L^* - p_H^*)$ still intended as a premium for the green firm or symmetrically as a penalty for the dirty producer.[39]

However, it is worth noting now that the main findings obtained for regions with low-income dispersion cannot be extended *tout court* to regions with high-income dispersion. In particular:

Lemma 3 *When $b > \tilde{b}$, at equilibrium we obtain a duopoly with the market covered at the limit for $\gamma \in (\widehat{\gamma}, b)$; on the contrary, the market is monopolized by the green producer whenever $\gamma \geq b$.*

Proof. See the Appendix. ■

Hence, while for $\gamma \in (\widehat{\gamma}, b)$ there is still room for both producers, such duopoly market is *covered at the limit,* namely $\theta_L = 0$ at the equilibrium $\theta_L = 0$. Finally, we confirm that a duopoly holds only when the social component of consumption does not exceed b, the highest WTP for the brown good. Whenever $\gamma \geq b$, then only the green firm is active, the brown producer being pushed off the market. For countries with high-income dispersion, we can state the following:

Proposition 2 *Under high-income dispersion ($b > \widetilde{b}$), for any $\gamma < b$ the unique equilibrium is a duopoly. At this duopoly equilibrium, the market is uncovered for $\gamma \leq \widehat{\gamma}(< b)$, while it is covered for $\gamma \in (\widehat{\gamma}, b)$. In contrast, whenever $\gamma \geq b$, the brown firm cannot be active in the market which is consequently monopolized by the green producer. At this monopoly equilibrium, the market is uncovered for $\gamma \in [b, \gamma^M)$, while it is covered at the limit for $\gamma \geq \gamma^M$.*

Proof. See the Appendix. ■

In line with the findings emerged in the case of low-income dispersion, we can observe two contrasting effects deriving from γ. On one hand, high values of γ entail a negative market-monopolization effect such that only the green producer can stay active in the market. On the other hand, in a subset of these values, a positive market coverage effect takes place so that the green producer is induced to cover the market, as even the poorest consumer is willing to pay a sufficiently high price due to the intensity of the social component of consumption. As for the duopoly outcome, there exists a new equilibrium with the market covered at the limit.

3.3 Low *versus* High-Income dispersion

It is worth noting that, while there are similarities between the equilibrium configurations arising for $b \leq \tilde{b}$ and for $b > \tilde{b}$, there exist some interesting differences between the two settings.

[38] Formal details can be provided by the authors upon request.

[39] Additional results and a formal demonstration can be provided upon request. However, as it replicates the analysis carried out in the previous section, we decided to not report it in the main text.

Indeed, quite intuitively, in both scenarios the green-low quality firm is better off when the social preference for the environment becomes more important. In particular, *ceteris paribus*, as γ increases, first the brown-high quality firm can no longer quote a price higher than the green-low quality firm (*price switch effect*) and then, for high enough values of γ, the brown firm exits the market that is consequently monopolized by the green firm (*market monopolization effect*). Finally, for extremely high values of γ, a positive *market coverage effect* takes place, with the green producer selling its variant to the whole set of consumers in the market. Nevertheless, when the income-dispersion is rather large, *i.e.* $b > \tilde{b}$, then at equilibrium the brown firm stays in the market for a wider range of γ-parameters than in the opposite case $b \leq \tilde{b}$.[40] In other words, the higher the income-dispersion, the higher the social component γ needed to push the brown firm off the market. As a conclusive point, we can state:

Proposition 3 *Ceteris paribus, the green firm monopolizes the market for a larger set of $\gamma-$parameters under low-income dispersion than under high-income dispersion.*

Proof. See the Appendix. ■

4 Institutions and environmental campaigns

In this Section we explore whether there is room for information disclosure programs providing consumers with precise data about the environmental quality of available products, depending on the country-specific income dispersion. By making consumers further aware of their possible contribution to global pollution *via* dirty shopping, these programs have a direct effect on the social component of consumption (γ), thereby altering the market structure at equilibrium. More precisely, we assume that the policy maker can affect γ by launching an environmental campaign at some costs $s\frac{\gamma^2}{2}$, with $s \geq 0$ being the marginal cost of the campaign.[41] It follows that social welfare writes:

$$SW = CS + \pi_L + \pi_H - D - s\frac{\gamma^2}{2}$$

where

$$CS = \int_{\max\{0,\theta_L\}}^{\min\{b,\theta_H\}} \left[(\theta q_L - p_L) + \gamma\left(q_H - q_L\right)\right] d\theta + \int_{\min\{b,\theta_H\}}^{b} \left[(\theta q_H - p_H) - \gamma\left(q_H - q_L\right)\right] d\theta,$$

and $D = e \cdot x_H$ represents the environmental damage deriving from global emissions.[42] It is worth remarking that the emissions coming from the green good are so low that they are not taken into

[40] See the proof of the next Proposition.

[41] This cost structure enables to model the stylized fact that it could be increasingly difficult to influence consumers' sensitivity towards environmental protection.

[42] The environmental damage is usually taken to be quadratic in the level of emissions. Our assumption of a linear environmental damage allows us to simplify calculations and obtain analytically tractable expression. However, the main results of our paper do not change if we consider alternative specifications, even if we would need to resort to numerical simulations.

account by the social planner in the damage function D, regardless of the cost required for increasing consumers' awareness to respect environment.[43]

In order to guarantee the concavity of the welfare function, we make the following assumption on the marginal cost s of the campaign:

Assumption 2.

$$s > \underline{s} \equiv \frac{(q_H - q_L)\left(12q_H^3 + 19q_H^2 q_L - 13q_H q_L^2 + 2q_L^3\right)}{q_L\left(4q_H - q_L\right)^2}. \tag{14}$$

We compare the social welfare of the different equilibrium market configurations and define the relevant emission thresholds that affect the optimal level of the campaign. Denote as $\underline{e}$ the minimum threshold level for the emissions to be considered worthy financing the campaign.[44] Our main results are gathered in the following Proposition:

Proposition 4 *The policy maker optimally affects consumers' environmental concern by setting a positive level of γ as long as the emissions level is sufficiently high ($e \geq \underline{e}$). This optimal level of relative preferences is non decreasing in e and reaches the maximum at $\overline{\gamma}$ for countries with low-income dispersion, and at b for countries with high-income dispersion.*

Proof. See the Appendix. ■

Firstly, given the cost of the campaign, it is socially desirable to affect the consumers' involvement in environmental protection from the social welfare viewpoint only if the damage generated from pollution is rather significant (that is $e \geq \underline{e}$).

Secondly, whenever the emissions coming from the brown good are extremely significant, then the optimal policy is to reduce the production of the polluting good as much as possible so that the social planner sets the optimal level of γ at either $\overline{\gamma}$ (for low-income dispersion) or b (for high-income dispersion).[45] Notice that the maximum optimal investment under low-income dispersion is lower than in the alternative case, namely under high-income dispersion. While this finding seems to be very reasonable, it means that the effort to reduce pollution must be stronger in countries characterized by high income dispersion. Indeed, in these countries (*e.g.* China and Russia) the public involvement in pollution abatement has bees so far very weak!

Finally, for intermediate values of e, the policy intervention does not change the market structure w.r.t. a laissez-faire case, that is the equilibrium is either an unconstrained duopoly or a duopoly with market covered at the limit. Looking at the equilibrium quantities, in both scenarios we find

[43] This assumption does not affect our results, as we will explain at the end of this Section.

[44] The threshold values of e appearing in this Section are left in the Appendix, along with the tedious calculations regarding different equilibrium configurations and welfare comparisons.

[45] In the Appendix we also demonstrate that the government always prefers to let the polluting firm serve the market instead of creating a monopoly for the green firm. However, in such duopoly the amount of emissions practically goes to zero.

that the low-quality quantity increases with γ whereas the high-quality quantity decreases with γ, as expected. However, what is really interesting is that total output either increases in γ (in the unconstrained duopoly equilibrium) or it is independent of γ (in the constrained duopoly equilibrium). Hence, consumer surplus never shrinks under such a policy instrument.[46] This has relevant policy implications. *First*, an environmental campaign does not generate *internal* conflicts between competition authorities (aiming at fostering competition) and environmental authorities (aiming at reducing pollution); as γ increases, one observes the reduction of the emissions but not at the cost of milder competition.[47] In addition, a possible *external* conflict regarding the carbon leakage effect does not appear in our setting as a result of consumers' preferences; polluting firms that relocate their production abroad no longer have a domestic market to cater. Our model suggests therefore a *market-driven* solution to both policy conflicts.

5 Conclusions

In this paper, we have considered a situation in which a "clean" and a "dirty" firm compete in the market by offering two vertically differentiated products that differently satisfy a social norm based on *green behavior* being associated to *good citizenship.* We have assumed that there exist two sources of differentiation: the performance of the good determines its *hedonic quality*, while the pollution emission indicates its *environmental quality.* Furthermore, we have assumed that the high (resp. low) hedonic quality variant is less (resp. more) complying with the norm compared with the alternative. Therefore, an environmentally friendly good satisfies the consumers' desire to stand out as a *good citizen*, however leaving them unsatisfied due to poor performance. Taking into account this conflict, two new results have emerged in our analysis in comparison with traditional settings of vertically differentiated goods. First, there exist circumstances whereby, although both firms are active at the market equilibrium, the one providing the low hedonic quality can quote a higher price than the rival because of the green nature of its good. Thus, at this duopoly equilibrium, a *price switch* is observed. Secondly, whenever the intensity of the relative preferences is sufficiently high, a *market-monopolization effect* takes place so that only the green firm can stay in the market, the "dirty" competitor being pushed off. At this equilibrium, for extremely high levels of relative preferences, the green monopolist extends the market coverage farther than what has been typically observed in a vertically differentiated setting, thereby inducing a *market-coverage effect.*

We have also shown that the equilibrium market configuration changes depending on the level of income dispersion; for example, a green producer monopolizes the market for a wider range of

[46] Notice that this result is not driven by the assumption that the emissions coming from the green good are very low (practically equal to zero in our formal model). Indeed, Mantovani and Vergari (2013), prove in a similar setting that the alternative policy of taxing the polluting firm causes a shrink in total output.

[47] As we already pointed out, there exist many situations where competition policy and environmental policy seem to clash, generating a trade-off between competition enhancement and environment protection.

parameters in countries with low-income dispersion rather than in countries where the dispersion is high. This finding is in line with the empirical evidence gathered so far; while in countries like China or Russia, where the per-capita income dispersion is rather significant, brown goods are still widespread, in countries with low per-capita income dispersion green productions tend to grow. An in-depth analysis of this issue from an empirical viewpoint is left for future research.

Finally, we have characterized the optimal campaign conducted by policy makers in order to sensitize consumers to the damage caused by pollution. First, we have highlighted that the level of investment in such environmental campaign can be country-specific. Second, we have found that, when it is socially beneficial to invest in such a campaign, then policy makers can induce pollution abatement while still preserving competition, regardless of the socio-economic conditions that we have considered. The policy implication suggested is that instead of focusing only on imposing taxes on polluting firms or introducing tradeable pollution permits, governments should actively support environmental campaigns in order to induce consumers to switch to green products. Interestingly, following recent data, top-selling cars in Norway are electric. At the end of 2013, the electric sports car Tesla Model S and the family electric car Nissan Leaf sold more than traditionally-fuelled cars.[48] The reasons for such a success were diverse, but a crucial factor is that Norway had been working for more than 30 years to raise awareness about electric vehicles.[49] Norwegians know what electric vehicles are and their impact on the environment, unlike average drivers in the US.[50]

[48] http://www.theguardian.com/environment/2014/jan/29/norway-electric-cars-sale

[49] Norway achieved such a result also by taxing gasoline-, diesel-, and natural gas–powered vehicles while providing incentives for electric vehicles.

[50] In a survey conducted by Navigant Research in November 2013 in the U.S., only 31% of respondents were familiar with the most common variants of electric cars sold in the market, such as the Nissan Leaf. Only 22% were aware of the existence of the Tesla Model S, which received a great deal of press coverage. See http://www.navigantresearch.com/newsroom/consumers-have-favorable-views-of-electric-vehicles-but-awareness-remains-low

Appendix

Proof of Lemma 1: By plugging (8)-(9) into (1)-(2), we get:

$$\begin{aligned}\theta_L^* &= \frac{\left(2cq_H + bq_Hq_L + 3\gamma q_Hq_L - bq_L^2 - 2\gamma q_H^2 - \gamma q_L^2\right)}{\left(4q_H - q_L\right)q_L},\\ \theta_H^* &= \frac{\left(2bq_H^2 - 3bq_Hq_L - 4\gamma q_Hq_L - cq_H + bq_L^2 + 3\gamma q_H^2 + \gamma q_L^2\right)}{\left(q_L - 4q_H\right)\left(q_L - q_H\right)}.\end{aligned}$$

Consider $\theta_H^* - \theta_L^*$, which amounts to:

$$\theta_H^* - \theta_L^* = \frac{\left(cq_L - 2cq_H + bq_Hq_L - 2\gamma q_Hq_L - bq_L^2 + 2\gamma q_H^2\right)q_H}{\left(q_L - q_H\right)\left(q_L - 4q_H\right)q_L}.$$

The denominator is positive, while the numerator is increasing in γ and nil at $\gamma = \check{\gamma} \equiv \frac{\left(2cq_H - cq_L - bq_Hq_L + bq_L^2\right)}{2q_H^2 - 2q_Hq_L}$. As $\check{\gamma}$ is decreasing in b and nil at $b = \underline{b}$, then for any $b > \underline{b}$ we obtain that $\check{\gamma} < 0$. The inequality $\gamma > \check{\gamma}$ is therefore always satisfied. This proves that, whenever $b > \underline{b}$, then $\theta_H^* > \theta_L^*$. In addition, for any $\gamma < \overline{\gamma}$, $p_H^* > 0$ holds. Finally, as we already know $\widehat{\gamma} > \overline{\gamma} \iff b < \widetilde{b}$, then in $b \in [\underline{b}, \tilde{b}]$ conditions $0 < \theta_L^* < \theta_H^* < b$, $slp_H^* > 0$, and $p_L^* > c$ simultaneously hold.

Proof of Lemma 2: Algebraic calculations reveal that: *(i)* $\theta_L^M \geq 0 \iff \gamma \leq \gamma_M$, and $\gamma_M > \overline{\gamma}$ in the relevant interval region $b \in [\underline{b}, \widetilde{b}]$. Also, *(ii)* $b > \theta_L^M$ when $\gamma > \frac{c - bq_L}{q_H - q_L}$. As $\overline{\gamma} > \frac{c - bq_L}{q_H - q_L}$, then $b > \theta_L^M$ always holds when $\gamma > \overline{\gamma}$.

Proof of Lemma 3: First of all, when $b > \widehat{b}$, then an interior duopoly solution with covered market cannot be sustained at equilibrium when $\gamma > \widehat{\gamma}$. Indeed, when $\gamma > \widehat{\gamma}$, we obtain that $\theta_L < 0$, as we know from Lemma 1. We should assume therefore that the demand for the low quality good starts at zero. This means that $x_L \equiv \theta_H$. Solving the corresponding *f.o.c.s* for the modified profit functions, the candidate equilibrium prices are $p_H^{'} = \frac{1}{3}[c + 2(b - \gamma)\left(q_H - q_L\right)]$ and $p_L^{'} = \frac{1}{3}[2c + (b + 2\gamma)\left(q_H - q_L\right)]$. Now we can substitute into (1) and (2) and check that $\theta_L^{'} < 0 < \theta_H^{'} < b$. Algebraic calculations reveal that $\theta_L^{'} < 0 \Leftrightarrow \gamma > \frac{2c + (b-\gamma)(q_H - q_L)}{3q_L}$, while $\theta_H^{'} > 0 \Leftrightarrow \gamma < b + \frac{c}{2(q_H - q_L)}$. However, the two conditions cannot be simultaneously satisfied given that $\frac{2c + (b-\gamma)(q_H - q_L)}{3q_L} > b + \frac{c}{2(q_H - q_L)}$, as it can be easily ascertained. In such a case, therefore, a duopoly equilibrium with the market covered at the limit becomes the equilibrium candidate. This candidate equilibrium configuration is characterized by a constrained price competition: as the market is covered at the limit, the indifferent consumer θ_L defined in (1) is set equal to zero, and demand functions are defined as $x_L = \theta_H$ and $x_H = b - \theta_H$. Accordingly, the equilibrium price of the green good is now $p_L^C = \gamma\left(q_H - q_L\right)$. Therefore, the best reply of the high quality firm implies $p_H^C = \frac{(b-\gamma)(q_H - q_L)}{2}$. Notice that the optimal price of the brown firm p_H^C is strictly positive *iff* $\gamma < b$; in such a case there is still room for both producers that cover the market at the limit. However, this duopoly structure no longer holds when $\gamma \geq b$.

Proof of Proposition 2: Consider the results coming from Lemma 3. In addition, when the market is monopolized, we know from the analysis developed under $b \leq \tilde{b}$ that, at equilibrium, it is profitable for the green producer not to cover the market for any $\gamma < \gamma^M$, while covering at the limit when $\gamma \geq \gamma^M$. Therefore, in this range of $b-$parameters where $b > \tilde{b}$, one needs to analyse the relationship between γ^M and b as to conclude about the market coverage. From standard computations, it immediately emerges that $\gamma^M > b \Leftrightarrow c > b(q_H - 2q_L)$. As q_H can be *a priori* lower than $2q_L$, then $\gamma^M > b$ can hold. Accordingly, we can conclude that, for $\gamma \in [b, \gamma^M)$ the monopoly is uncovered, while it is covered at the limit for $\gamma \geq \gamma^M$.

Proof of Proposition 3: From Propositions 1 and 2 we know that under low-income dispersion, i.e. $b \leq \tilde{b}$ (resp. under high-income dispersion, i.e. $b > \tilde{b}$), the green firm monopolizes the market for $\gamma > \overline{\gamma}$ (resp. $\gamma > b$). For the result, it suffices to note that the inequality $b > \overline{\gamma}$ is always satisfied.

Proof of Proposition 4: Let us start from low-income countries, where $b \in [\underline{b}, \widetilde{b}]$. As long as $\gamma < \overline{\gamma}$, both firms are active in the market and competition is unconstrained. Social welfare at equilibrium as a function of γ writes:

$$SW^*(\gamma) = \pi_L^* + \pi_H^* + CS_L^* + CS_H^* - e \cdot x_H^* - s\frac{\gamma^2}{2},$$

with

$$x_L^* = \frac{q_H\left[(q_H - q_L)(2\gamma q_H - q_L) - c(2q_H - q_L)\right]}{q_L(4q_H - q_L)(q_H - q_L)},\ x_H^* = \frac{p_H^*}{(q_H - q_L)};$$

$$\pi_L^* = \frac{q_L}{q_H}(q_H - q_L)(x_L^*)^2,\ \pi_H^* = \frac{(x_H^*)^2}{(q_H - q_L)},$$

$$CS_L^* = \int_{\theta_L}^{\theta_H}\left[(\theta q_L - p_L) + \gamma(q_H - q_L)\right]d\theta = \frac{(x_L^*)^2}{2},$$

$$CS_H^* = \int_{\theta_H}^{b}\left[(\theta q_H - p_H) - \gamma(q_H - q_L)\right]d\theta = \frac{(x_H^*)^2}{2} \cdot q_H\left[(2b + \gamma)\left(q_H^2 - q_L^2\right) - c(3q_H + 2q_L)\right].$$

Maximising this welfare function w.r.t. γ, we obtain:

$$\gamma^* = \frac{q_H\left(cq_Hq_L - 12cq_H^2 - 3bq_L^3 + cq_L^2 + 11bq_Hq_L^2 - 8bq_H^2q_L\right) + e\,q_L(4q_H - q_L)(3q_H - q_L)}{s\,q_L(4q_H - q_L)^2 - (q_H - q_L)\left(12q_H^3 + 2q_L^3 - 13q_Hq_L^2 + 19q_H^2q_L\right)}.$$

It is worth noting that:

$$\begin{aligned}\gamma^* &\geq 0 \iff \\ e &\geq \underline{e} = \frac{q_H\left[q_Lb(8q_H - 3q_L)(q_H - q_L) + c(3q_H - q_L)(4q_H + q_L)\right]}{q_L(q_L - 4q_H)(q_L - 3q_H)},\end{aligned}$$

and

$$\begin{aligned}\gamma^* &\leq \overline{\gamma} \iff \\ e &\leq \overline{e} = \frac{q_H\{(q_H - q_L)^2(6q_H - q_L)\left[c - b(q_H + q_L)\right] + s[c + 2b(q_H - q_L)](4q_H - q_L)q_L\}}{q_L(q_H - q_L)(3q_H - q_L)^2}.\end{aligned}$$

Next, we wonder whether there are values of e such that the policy maker has incentives to further push γ so as to reach the monopoly outcome. Recall that for $\gamma \geq \overline{\gamma}$, the unique equilibrium is a monopoly with only the low-green quality firm in the market, the brown firm being no longer active. In this case, *i.e.*, $\gamma \in [\overline{\gamma}, \gamma_M)$, equilibrium quantities and the welfare as a function of γ are:

$$x_L^M = \frac{c - bq_L - \gamma\left(q_H - q_L\right)}{2q_L},\ \pi_L^M = \left(x_L^M\right)^2 q_L,$$

$$CS_L^M = \frac{\left(x_L^M\right)^2}{2} q_L,\ SW^M\left(\gamma\right) = \pi_L^M + CS_L^M - s\frac{\gamma^2}{2}.$$

Maximising this welfare function, we find the following optimal level of γ:[51]

$$\gamma_M^* = \frac{3\left(q_H - q_L\right)\left(c - bq_L\right)}{3\left(q_L - q_H\right)^2 - 4sq_L}.$$

Note however that $\gamma_M^* < \overline{\gamma}$, showing therefore that, under Assumption 2, it is never socially profitable to set a level of γ larger than $\overline{\gamma}$.

Finally, we can demonstrate that, when $\gamma \to \overline{\gamma}$, the government prefers to keep the high quality polluting firm in the market instead of creating a monopoly for the green firm. For $\gamma = \overline{\gamma}$, social welfare $SW^M\left(\gamma\right)$ would result in:

$$SW^M\big|_{\gamma=\overline{\gamma}} = \frac{3(2q_H^2 - 3q_Hq_L + q_H^2)^2[c - b(q_H + q_L)]^2 - 4sq_H^2q_L[c + 2b(q_H - q_L)]^2}{8q_L(3q_H^2 - 4q_Hq_L + q_H^2)^2}$$

Using an ϵ reason, the government can alternatively select $\gamma = \overline{\gamma} - \epsilon$ and leave the high- quality producer in the market. For $\epsilon \to 0$, social welfare $SW^*\left(\gamma\right)$ is:

$$SW^*|_{\gamma=\overline{\gamma}-\epsilon} = \frac{q_H\{(3q_H - 2q_L)(q_H - q_L)^2[c - b(q_H + q_L)]^2 - sq_Hq_L[c + 2b(q_H - q_L)]^2\}}{2q_L(3q_H^2 - 4q_Hq_L + q_H^2)^2}.$$

It is immediate to verify that:

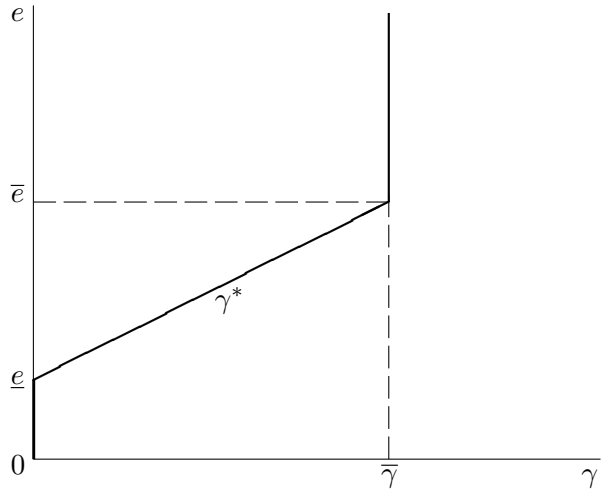
$$SW^*|_{\gamma=\overline{\gamma}-\epsilon} - SW^M\big|_{\gamma=\overline{\gamma}} = \frac{(4q_H - 3q_L)[c - b(q_H + q_L)]^2}{8(3q_H - q_L)^2} > 0.$$

As a consequence, the government prefers to leave the high quality firm in the market also when $e \geq \overline{e}$, although fixing a value of γ such that its demand, and therefore its polluting emissions, are practically driven to zero.

The following picture represents the optimal level of γ in the low income countries:

[51] Given assumption 2, this welfare function in concave in γ.

Figure 1 : optimal campaign in the low income country



In the case of high-income countries (for any $b > \widetilde{b}$), as long as $\gamma < \widehat{\gamma}$, both firms are active on the market and competition is unconstrained. As in the previous case, in this range of parameters it is optimal to undertake campaign initiatives, thereby setting $\gamma = \gamma^*$. As before, γ^* takes positive values for $e \geq \underline{e}$. However, we here need to verify that $\gamma^* < \widehat{\gamma}$. This holds when

$$e < \overline{e}' = \frac{(q_H - q_L)[b(q_H - q_L)(q_H^2 - 8q_H q_L + 2q_L^2) - cq_H(13q_H - q_L)] + s(4q_H - q_L)[2cq_H + bq_L(q_H - q_L)]}{(3q_H - q_L)(2q_H^2 - 3q_H q_L + q_L^2)}.$$

It follows that, when $e \in (\underline{e}, \overline{e}']$, the optimal investment level is $\gamma^* \in (0, \widehat{\gamma})$, and the social welfare is given by $SW^*(\gamma)$. However, in the case when γ is driven by the policy maker towards the limit $\widehat{\gamma}$, the resulting market share of the polluting firm is $\varepsilon \to 0$. In particular, at $\gamma = \widehat{\gamma}$, the social welfare corresponds to the following expression:

$$\begin{aligned} SW^*|_{\gamma=\widehat{\gamma}} &= \frac{c^2 q_H \cdot \Lambda - 2cq_H (q_H - q_L) \cdot \Sigma + b (q_H - q_L)^2 \cdot \Psi}{2(2q_H^2 - 3q_H q_L + q_L^2)^2} \\ \Lambda &= [3q_H^2 - 2q_L^2 - q_H(q_L + 4s)] \\ \Sigma &= [b(3q_H^2 - 8q_H q_L + 5q_L^2 + 2sq_L) - e(2q_H - q_L)] \\ \Psi &= \{b[3q_H^3 - 3q_H^2 q_L + 3q_H q_L^2 - q_L^2(2q_L + s)] - 2e(2q_H^2 - 3q_H q_L + q_L^2)\} \end{aligned}$$

where the emissions coming from the polluting firm are far from being irrelevant.

Next, we consider what happens when $e > \overline{e}'$. In this case, the policy maker may have the incentive to set $\gamma > \widehat{\gamma}$. Recall from the analysis above that for $\gamma \in (\widehat{\gamma}, b]$, we have a corner solution with covered market and both firms active on the market. Social welfare at equilibrium is as follows:

$$SW^{**}(\gamma) = \pi_L^{**} + \pi_H^{**} + CS_L^{**} + CS_H^{**} - s\frac{\gamma^2}{2} - ex_H^{**}$$

with

$$x_L^{**} = \frac{1}{2}(b+\gamma), x_H^{**} = \frac{1}{2}(b-\gamma)$$

$$\pi_L^{**} = \frac{1}{2}(b+\gamma)[\gamma(q_H - q_L) - c],\ \pi_H^{**} = (q_H - q_L)(x_H^{**})^2$$

$$CS_L^{**} = (x_L^{**})^2 \frac{q_L}{2},\ CS_H^{**} = \frac{1}{8}(b-\gamma)[(b-\gamma)q_H + 2(b+\gamma)q_L].$$

One can easily find that $SW^*|_{\gamma=\widehat{\gamma}} = SW^{**}|_{\gamma=\widehat{\gamma}}$, thus verifying the continuity of the social welfare function. Maximising $SW^{**}(\gamma)$ with respect to γ, we find the following socially optimal value of γ:[52]

$$\gamma^{**} = \frac{2(c-e) + b(q_H - q_L)}{7(q_H - q_L) - 4s}.$$

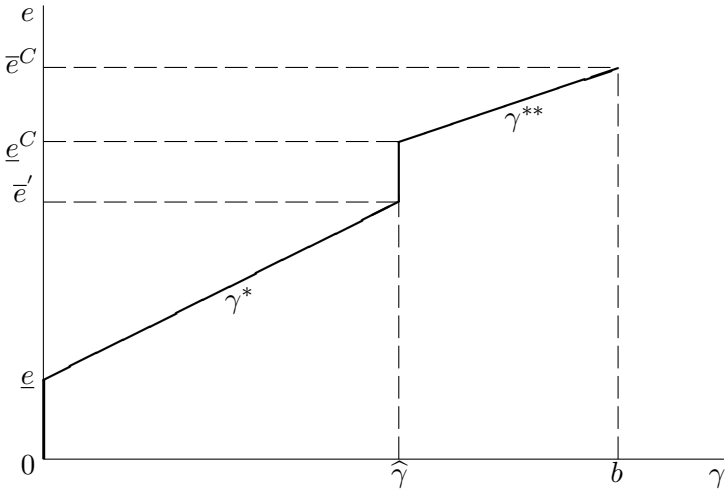
with $\gamma^{**} \geq \widehat{\gamma} \Leftrightarrow e > \underline{e}^C = \frac{b(q_H - q_L)[q_H^2 - 5q_H q_L + 2q_L(2q_L + s)] - c[5q_H^2 - q_L^2 - 4q_H(q_L + s)]}{(2q_H - q_L)(q_H - q_L)}$ and $\gamma^{**} < b \Leftrightarrow e < \overline{e}^C = c - b(3q_H - 3q_L - 2s)$ (superscript C indicates the threshold values for the corner case). Note that $\overline{e}' < \overline{e}^C$. It follows that, in $e \in (\overline{e}', \underline{e}^C]$, the optimal solution γ^{**} is not viable as it would take a value lower than $\widehat{\gamma}$. In such an interval, therefore, the optimal investment is $\widehat{\gamma}$. However, when $e > \overline{e}^C$, the policy maker has the incentive to set $\gamma^{**} = b$ so to have a corner solution with covered market and both firms active on the market.

Finally, note that in the duopoly with market coverage total output is independent of γ. Thus, as in the unconstrained duopoly, the policy instrument γ does not have a distortive effect on market competition. Similarly to the previous scenario, it is never socially desirable to further push γ so as to let the green firm to monopolize the market. Quite intuitively, indeed, as $\gamma \to b$, the market share of the brown firm tends to zero and likewise, the polluting emissions. Notice, however, that competition is preserved. Moreover, increasing γ above b would imply changing the market from a duopoly with covered market to a monopoly with uncovered market.

The following picture represents the optimal level of γ in high income countries:

[52] Assumption 2 suffices to guarantee the concavity of $SW^{**}(\gamma)$. More precisely, $SW^{**}(\gamma)$ is concave when $s > 7(q_H - q_L)/4$, but such a value is lower than $\underline{s}$.

Figure 2 : optimal campaign for the high income country



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