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Tax Exemptions of Ethical Products Revisited

Dina KASSAB*

Abstract

Corporate social responsibility (CSR) activities, being viewed as the corporate's provision of a public good, enable tax exemptions in many economies. This paper examines whether these tax exemptions are justified, given the nature of interdependence between the public good provided by the firm and that provided through the government, and the form in which the exemptions - or taxes - are best imposed. In our theoretical analysis, we model a profit-maximizing firm, in a monopoly setup, in the presence of a continuum of consumers with heterogeneous preferences towards the CSR content of the private good they purchase. Consumption of the ethical product is further assumed to confer a reputational gain that increases as the pool of consumers purchasing the good narrows. The analysis suggests that tax exemptions ought to be accorded to CSR activities when private and public investments are perfect substitutes, and an ad valorem subsidy is welfare superior to a specific one. However, when the firm's CSR investment complements the government's provision, the firm's product should be subject to taxes when there is a sufficiently large marginal willingness to pay for such activities. An ad valorem tax serves as a purely corrective device to balance the relative shares of the firm and the government in the public good provision whilst a specific tax redistributes surplus form the firm to consumers while increasing total welfare in the process. Conditions for optimality of each tax instrument are discussed.

JEL classification: M14, H41, D6, H11, L21

Keywords: Corporate Social Responsibility, Progressive Tax, Consumption norms, Ad valorem tax, Specific Tax.

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1 Introduction

The economists' view of how society should be organized has rested on two pillars. The invisible hand of the market harnesses consumers' and corporations' pursuit of self-interest to the pursuit of efficiency. Whenever externalities stand in the way of efficiency, the state corrects market failures and redistributes income and wealth, as the distribution generated by markets has no reason to fit society's moral standards. From this perspective, it was only natural to think that the State is the sole provider of public goods as their provision is subject to free-riding problems and hence cannot be left in the hands of individuals. With the rise of government failures, society's demands for individual and corporate social responsibility as an alternative response to market and redistributive failures have become more prominent. Government failures can find its origins in the capture by lobbies and other interest groups. Governments under influence may fail to optimally correct externalities, or bend to wealthy agents' opposition to redistributive policies. Governments may also fall due to inefficiency, high transaction costs or poor information. So citizens and corporations empower themselves and substitute for elected government. The movement is gaining momentum and the Private Provision of Public Goods is being revisited.

Many public goods are privately provided either through direct contributions by individuals or by firms as part of their marketing or business strategy, what we call *Corporate Social Responsibility* practices. Provision of public goods using direct contributions has been studied extensively. In contrast, there has been relatively little work on private provision by firms. The economics literature on private provision of public goods has focused on the direct contributions mechanism. The general assumption of theoretical research in this area is that individuals choose between consumption of a private good and contributions to a pure public good. Yet individuals increasingly face a third option: consumption of impure public goods that generate private and public goods as a joint product. Markets for socially responsible goods or goods with public add-ons exemplify the increased availability of impure public goods in the economy.

For example, consider the growing market for fair trade coffee, which is coffee produced under high social and environmental standards. The producers of fair trade coffee are paid a higher price than standard coffee in order to promote healthier working conditions for farmers and fair wages. Fair trade premiums are then invested in community development projects like scholarship programs, healthcare services and quality improvement training. Consumers increasingly have the option to purchase fair trade coffee with a price premium. In return, production of fair trade coffee raises the living standards of farmers and farm workers and helps develop the community. Thus consumers of fair trade purchase a joint product—coffee consumption and community development. Another example is the growing market for premium-priced products which are linked to a social cause. This is the case of cause-related marketing[1] and lump-sum corporate

[1]The practice of explicitly linking the sale of a company's product to company contributions to worthy

donations to or expenditures on worthy causes or green activities, which implicitly link the contribution to sales of the company's products. Thus consumers of such products also purchase a joint product - consumption of the private good and investment in the social cause embraced by the firm. In all these examples, the joint product forms an impure public good, with private and public characteristics.

This paper has been motivated by the ongoing discussion among economists about the market and welfare implications of Corporate Social Responsibility (CSR hereafter) or "a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on voluntary basis" (European Commission, 2001). CSR activities being viewed as the corporate provision of a public good, it is a common practice in many economies that they enable tax exemptions. For instance, The Chilean government offers a variety of tax credits to corporations for charitable donations, most of which are oriented to support educational activities, such as schools, universities, and vocational institutions. Italy has introduced an ecolabelling scheme that provides the purchaser with a sales tax reduction on the purchase price of green products (Bell, 2002). In the U.S, tax exemptions are designed so as to promote the adoption of hybrid-electric vehicles (Diamond, 2009). The World Bank identifies those tax incentives as an effective means by which governments can fullfill their role in promoting CSR (Fox et al., 2002).

The present paper investigates whether these exemptions are justified, given the nature of interdependence between the public good provided by the company and that provided through the government. For instance, should the same tax exemptions apply to a firm constructing a school for children in a poor neighbourhood and one that incorporates a number of billable hours for its employees to volunteer in public schools? Should the tax policy distinguish between a company donating to build a hospital for cancer patients and one that donates to paint the walls or provide complementary equipment for a public hospital?

The understanding of CSR has matured among both scholars and practicioners. It is about time the focus of the analysis and debates shifts from the *desirability* and *feasibility* of CSR to the *regulation* of CSR, to get the most out of it. Firms' intervention on the market to correct government failures is sometimes necessary, but so is the government's intervention to correct CSR failures and capitalize on its benefits. In doing so, the regulator ought to draw a clear distinction between the different practices, according to whether they complement or substitute for the government provision of the public good. A priori, companies investing in clean energy resources, reducing carbon footprint or providing access to clean water in deprived areas and those enhancing work conditions for their employees or providing some paid staff time to charitable causes should receive a differential treatment, given the public policy objectives of course.
The objective of this study is then three-fold: (i) to model consumers' utility when

causes.

consumption externalities are relevant, (ii) to compare the effects of an ad valorem tax vis-à-vis a specific one in a market with CSR, and (iii) to provide guidelines for policy makers to determine the optimal way to intervene on a market with CSR activities.

Our model examines a market consisting of consumers with heterogenous preferences towards CSR in a monopoly market where consumers account for how they are perceived when they make their purchasing decision. All along, we assume that only those who buy a firm's product experience a warm-glow and prestige utility and pay for it. CSR being a public good, non-buyers free ride on the warm glow of buyers to derive a social utility from CSR. A benevolent regulator intervenes on the market by imposing either an ad valorem or a specific tax, the collected tax revenues are then recycled in the form of the government provision of a public good, which can either complement or substitute for the CSR investments of the monopolist. Our main finding is that while tax exemptions are always welfare improving when the CSR investment susbstitutes for the government provision of the public good, taxing the product with a public add-on can be optimal in the complementarity case. Furthermore, while an ad valorem subsidy is welfare superior to a specific one, a specific tax dominates ad valorem taxation under certain conditions.

The paper is organized as follows. The next section provides a literature review. Section 3 introduces the basic model. Section 4 contrasts the effects of an ad valorem tax and those of a specific one imposed on the private good with a public add-on. The welfare maximizing taxes are examined in Section 5. Section 6 concludes.

2 Related literature

Our research draws on the confluence of three diverse streams of literature: consumer behavior with social externalities, strategic CSR and market outcomes and finally CSR and regulation.

Consumer Behavior with Social Externalities Classic economic models view consumers as rational individuals concerned solely with their own well-being. While this standard analysis undoubtedly has an important role in explaining many aspects of consumer behavior, it does not explain consumers' prosocial attitudes, precisely, why consumers would contribute to a public good in a non-cooperative setting, even though there is an underlying free-rider problem. Andreoni (1990) introduces into the utility of individuals a *warm glow* component or joy of giving; consumers derive some private benefit from the consumption of the private and public goods, but also from the contribution to the public good itself. This altruistic motive behind prosocial behavior is a form *socially directed preferences* as opposed to the *socially embedded preferences*, both discussed in Dasgupta et al.(2016). While the former describe the case where individuals have a concern for the welfare of others and hence their consumption decisions take account of the consequences they impose on others, the latter reflect the idea that consumers care about their consumption relative to the average consumption of their peers or a reference group. These models assume that consumers differ in their degree of morality

which is their private information and has to be inferred from one's actions. Individuals then use their consumption to signal either their conformity or adherence to a certain group (Bernheim, 1994), enhance self-image (Ellingsen and Johannesson, 2008) or seek distinction or some reputational payoff (Bénabou and Tirole, 2010).

Strategic CSR and market outcomes On the supply side, firms are assumed to be socially responsible because they anticipate a benefit from such a behavior. Our work is related to the strand of theoretical literature that addresses conditions under which firms engage in CSR and its welfare implications (see Crifo and Forget, 2014; Kitzmueller and Shimshak, 2012). In particular, our contribution is more closely related to theoretical research where CSR is a business strategy in imperfect competition that generates product differentiation or ameliorates information asymmetries between consumers and producers (Baron, 2001; Chen, 2001; McWilliams and Siegel, 2002; Manasakis et al., 2007; Banerjee and Wathieu, 2017). Research suggests that competition may enhance CSR investments by firms as a means of product differentiation (Bagnoli and Watts, 2003; Polischuck and Firsov, 2005). However, competition could also lead to lower levels of CSR, as compared to monopoly, due to the smaller market served by each firm (Bagnoli and Watts, 2003; Bennett et al., 2013; Branco and Villas-Boas, 2015).

CSR and Regulation The Literature on CSR and regulation has evolved along two parallel lines: eco-labeling and green tax policies. *Eco-labeling* analyzes the value of certified or noncertified claims that the product meets the objectives of green consumers. The literature on eco-labeling makes the assumption that the "social responsibility" attribute of a product is a credence good in the sense that consumers cannot actually monitor the firm's CSR activities. Hence, in the absence of a credible information disclosure mechanism about social responsibility attributes of the firm's products to consumers, firms will fail to persuade consumers about their true commitment to social values, thus, a *market for lemon* problem arises. Mitrokostas and Petrakis (2007) analyze, in a duopoly setup, the case where the regulator intervenes to solve this problem by proposing a certain standard of CSR effort to the firms and providing certification to the firms that comply with the standard. They find that government intervention actually increases total welfare since it gives both firms incentives to engage in CSR activities. In Manasakis et al. (2013), the analysis is extended to allow for different objectives of the regulator. The authors investigate the impact of alternative certifying institutions on firms' incentives to engage in costly CSR activities as well as their relative market and societal implications. They find that the CSR certification standard is the lowest under for-profit private certifiers and the highest under a Non Governmental Organization (NGO), with the standard of a welfare-maximizing public certifier lying in between. In this paper however it is assumed that the firm can credibly inform consumers about their CSR effort by using labels on their products or by publishing reports about their CSR activities, but compare different objectives of the regulator when setting a consumption tax on CSR products.

Much research has focused on the effectiveness of *green tax policies*. These are regu-

latory policies that consist in imposing emission taxes on some products and giving subsidies to green products to encourage environmentally responsible production, the public good in question being the reduction of pollution. An interesting idea that emerges from the analysis of environmental taxes is that of the *double dividend* (Pearce, 1991; Goulder, 1995; Bovenberg and De Mooij, 1994). A green tax reform or a tax swap whereby an ecotax[2] is levied and the proceeds are devoted to decrease some other distortionary tax while keeping government income constant, may achieve a double dividend, that is (i) an increase in environmental quality, the *green dividend* and (ii) an increase in welfare from private commodities, the *blue dividend*. The double dividend hypothesis has been tested taking into account the different impacts an environmental tax may have. Most relevant to our analysis is the case where the proceeds of taxation are used to finance a public good such as a public pollution abatement activity (John et al., 1995) and taking into account the heterogeneity in households income, which translates into the degree of regressivity in the environmental tax (Chiroleu-Assouline and Fodha, 2014).

Although we do not use a general equilibrium model where the tax proceeds are recycled to reduce some other distortionary tax, our analysis suggests the possibility of a double-dividend occuring from taxing products *with* a CSR content. The green dividend is then the higher public good that could be achieved through both the CSR investments and the public investment that the tax allows, and, by remote analogy to the double-dividend theory, the additional redistributional benefit that taxing the CSR product enables can be interpreted as the blue dividend. In some cases, taxing CSR products can serve as a means of redistribution by narrowing the pool of green consumers purchasing the good. If altruistic motives are assumed to be correlated with income, the tax payers will then be the consumers at the higher end of the distribution of income who pay larger taxes to make the public good available for all.

3 Benchmark Model

In what follows we set up the benchmark model starting from the basic assumptions (Section 3.1), and proceeding with the presentation of mechanisms underlying the optimal choice of the producer (Section 3.2).

3.1 Preliminaries and basic assumptions

Consider a monopolist selling a private good at a price p in a market consisting of a continuum of consumers. Alongside the private good production, the monopolist engages in CSR activities to generate a public good. Precisely, for each unit of the private good sold, the firm undertakes a CSR investment of value $s \geq 0$.

Consumers' preferences On the demand side, there is a unit mass of consumers, each indexed by i and having a unit demand $q_i \in \{0, 1\}$. Consumers have identical preferences regarding the private good. However, owing to variation in education, morality and other

[2]An eco tax or environmental tax is a positive tax on carbon dioxide emissions

personal traits, they are heterogeneous regarding their willingness to pay for the CSR activities that are undertaken by the firm and $\theta_i \in [0,1]$ is introduced to account for this heterogeneity, with a larger θ denoting a higher social consciousness. We further assume that the realization of θ_i is private information of consumer i, it follows a cumulative distribution $F(\theta)$ and density $f(\theta)$ that are common knowledge. Let β and α denote the baseline marginal warm-glow utility from CSR and the marginal utility from the private good consumption. Also let the reputational benefit from buying the *ethical* version of the product be $r(s,p)$ and the overall level of public good be Y. Consumer i then derives a utility $u_{i1} = \beta s - \frac{1}{2}(1-\theta_i)s^2 + r(s,p) + \alpha - p + Y$ if he buys the good, and $u_{i0} = Y$ otherwise. This utility function captures both forms of motives behind prosocial consumption identified in the literature (Dasgupta et al., 2016):

- *Socially-directed preferences* are reflected by the warm glow utility $\beta s - \frac{1}{2}(1-\theta)s^2$, with utility functions that are concave in s, and the rate of decrease of the marginal warm glow utility being dependent on consumer's social consciousness θ_i. For any given level of CSR undertaken by the firm, s, the marginal warm glow utility is larger the more caring the consumer is. Furthermore, as the amount of the contribution increases, the more altruistic consumers experience a lower decrease in their marginal utility. In other words, all consumers are assumed to be altruistic to some extent as they derive a positive utility from the act of contributing to the public good per se. However, as the amount of contribution increases, the least caring consumers experience a larger decrease in their marginal utility from contributing as for this group the increase in the contribution would be judged exagerated or unnecessary. Heterogeneity is then seen as individuals having different morally ideal efforts that they seek to achieve and self-image value depends on how close their contribution is to that optimal level.

- The reputational benefit from buying the green product, $r(s,p)$, accounts for the *socially-embedded preferences*. Consumers derive a positive utility from being seen as responsible consumers that we refer to as the *prestige or distinction utility*, r. This can be interpreted as consumers caring about the opinion others have of them. This assumption is consistent with the empirical findings of the literature (Cronson and Treich, 2014, pp.7-8).[3] Following Bénabou and Tirole (2010), we assume that this reputational gain from belonging to the group of responsible consumers emerges endogenously as it will be determined by the characteristics of this particular group at equilibrium.

Furthermore, in the terms of Besley and Ghatak (2007), all consumers are assumed to be *caring*, in the sense that they all care about the overall level of public good available in the economy Y. This particular utility however is independent of their purchase decisions since the weight attributed to each is too small to affect the outcome.

[3]The authors give several examples on the importance of social prestige as a determinant for prosocial behavior such as purchasing hybrid cars, installing solar panels (versus indoor energy-efficient investments).

For the sake of simplicity, we assume that θ is uniformly distributed. Consumer i decides to buy the good if $\Delta u_i = u_{i1} - u_{i0} \geq 0$, that is if

$$\theta_i \geq \frac{p - \alpha - \beta s + \frac{s^2}{2} - r(s,p)}{\frac{s^2}{2}} \equiv \hat{\theta}(s,p)$$

Hence, there exists a threshold type $\hat{\theta}(s,p)$ above which consumers decide to purchase the good and below which they abstain. The prestige utility can now be formally defined. It is the expected value of the social consciousness of the group of responsible consumers compared to that of the most caring type:

$$r(s,p) = E(\theta_i | q_i = 1) - \theta^{max} = E(\theta_i | \theta_i \geq \hat{\theta}) - 1$$

with $E(\theta_i|\theta_i \geq \hat{\theta}) = \frac{\int_{\hat{\theta}(s,p)}^{1} \theta f(\theta) d\theta}{1 - F(\hat{\theta})}$ being the conditional mean in the upper tail of the distribution of θ. This reputational gain takes into account both the value of $\hat{\theta}$ and the weight attributed to $\theta_i \geq \hat{\theta}$, i.e. to which degree the product in question is a *niche* product. In the uniform case, the prestige utility then amounts to $r(s,p) = \frac{\hat{\theta}(s,p)-1}{2}$. Note that the reputational gain from being a *responsible* consumer thus increases as the pool of these consumers narrows, i.e. the more it becomes a niche good that only the highest types purchase. Plugging this term into the consumer's incentive constraint, the threshold type $\hat{\theta}$ can now be written as $\hat{\theta}(s,p) = \frac{2(p-\alpha-\beta s)+s^2+1}{s^2+1}$. The individual demand of consumer i now reduces to:

$$q_i(\theta_i, s, p) = \begin{cases} 1 & \text{if } \theta_i \geq \hat{\theta}(s,p) \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

which can be integrated over the interval $[0,1]$ to obtain the aggregate demand:

$$Q(s,p) = \int_{\hat{\theta}(s,p)}^{1} q_i(\theta_i) f(\theta) d\theta = \frac{2(\beta s - p + \alpha)}{s^2 + 1} \tag{2}$$

which always decreases in the price set by the monopolist but may increase or decrease with the per unit contributions to social causes, depending on the CSR-price bundle offered on the market.

3.2 Choice of the CSR-price bundle

Assuming a constant marginal cost of production of the private good $c \geq 0$ and given the cost function of CSR $C(s) = sQ$, the firm decides simultaneously on the per unit monetary contributions donated to social causes, s^u, and the price to be charged, p^u, such that

$$(s^u, p^u) = \underset{(s,p)}{\text{argmax}}[(p - s - c)Q(s,p)]$$

Consider the firm's pricing rule obtained from the above maximization problem:[4]

$$p^u(s) = \frac{\beta + 1}{2} s^u + \frac{\alpha + c}{2} \tag{3}$$

with the coefficient of s in the first term being the weight of CSR in the price the monopolist charges, i.e. the unit price of the contributions to social causes and and the second term being the part of the price of the private component of the good. The optimal price thus consists of the per unit investment in the public good weighted by the premium he is able to charge for his CSR activities, and the monopoly price absent any CSR efforts. The choice of the CSR-price bundle is given in the following proposition :

Proposition 1. *The monopolist choice of the CSR-price bundle is given by*

$$(s^u, p^u) = \left[\frac{\beta - 1}{\alpha - c}, \frac{\beta^2 - 1 + \alpha^2 - c^2}{2(\alpha - c)} \right]$$

if $\beta > 1$ *and* $\alpha > c$ *and* $(s_0^u, p_0^u) = (0, \frac{\alpha + c}{2})$ *otherwise. (proof in the appendix)*

By engaging in corporate social responsibility, the monopolist makes his product more valuable to consumers. However, he also incurs a cost by doing CSR. A necessary condition for the producer to engage in CSR is that the *highest* marginal warm-glow utility from CSR,[5] β, must be larger than the marginal cost of increasing CSR to the firm, which is 1 dollar. Thus, only when consumers, at least the most altruistic ones, place a sufficiently high value on CSR will the firm practice it. Since offering a positive contribution to the public good alongside the private one requires raising the price, the firm cannot engage in CSR unless the willingness to pay for the private good itself covers marginal cost of production, otherwise no one would be willing to buy the good. This condition together with (3) imply that it is always the case that the premium on CSR exceeds 1.

Lemma 2. *In a monopoly setup, each dollar contributed to social causes via the purchase of the impure public good costs the consumer more than one dollar.*

This result will be of interest for the welfare analysis, particularly, for the discussion of the surplus distribution between the consumers and the firm. Proposition 1 also highlights an important result. The optimal choice of CSR component of the product is equal to the marginal profitability of CSR activities relative to that of the private good. Consequently, any factor that decreases the profit from selling the private good induces the monopolist to invest more in CSR, and this is what we call the *make-up effect*; as if the producer had two businesses: selling the private good and investing in the public good, so that he could make up for the lower profitability of the former by

[4]This result is obtained fom the first-order condition of the monopolist's maximization problem with respect to the price.

[5]A simple derivation of the warm-glow utility with respect to s yields $\frac{\partial u_{i1}^w}{\partial s} = \beta - (1 - \theta_i)s$, which reduces to β when $\theta_i = 1$.

a higher investment in the latter. The CSR component of the product increases the lower the willingness to pay for the private good, α and the larger the marginal cost of its production, c. That is, a producer may choose a high CSR content of the good just because he is inefficient in the production (as captured by a high c) or the private good he sells is not strongly demanded on the market. The intuition behind this result is that the higher the cost of production, the more it pays for the firm to use CSR to expand the demand of its product or be able to charge a higher price for the CSR-private good bundle.[6] The following equations then characterize the equilibrium in the unregulated monopoly:

$$\begin{aligned} Q^u =& \alpha - c \\ \pi^u =& \frac{(\alpha + c)^2 + (\beta - 1)^2}{2} \\ S^u =& \beta - 1 \end{aligned} \tag{4}$$

In this setup, CSR is welfare-improving if consumer's sensitivity to such activities, as captured by β, is sufficiently large. The following lemma formalizes this statement.

Lemma 3. *CSR is welfare improving iff* $\beta > \frac{\sqrt{2}\sqrt{3(\alpha-c)+2}+1}{3}$ *(proof in the appendix)*

Relative to the case with no CSR, where the market outcomes coincide to the standard monopoly, CSR results in a higher price and larger profits for the firm, with the quantity produced remaining unchanged. Introducing CSR on the market enhances consumers' surplus only if the average interest in CSR is sufficiently large relative to the marginal utility from the private good, that is if $\frac{(\beta-1)^2}{4} + (\beta - 1) > \frac{\alpha-c}{2}$ (proof in the appendix). Recall that, as the average interest in CSR activities, as represented by a larger β, increases, the monopolist increases, not only the per unit CSR efforts, but also the prime on CSR. The price then increases, and this has two sets of effects on consumers' surplus. On the one hand, a group of consumers is excluded from the market and experiences a loss in warm glow utility and in utility from the consumption of the private good that we assume to be unavailable otherwise. On the other hand, the remaining buyers have an increase in their prestige utility and all consumers derive a positive utility from the increased level of public good given by $Y = sQ = \beta - 1$. Thus the overall gain exceeds the loss of the excluded group only if consumers put a sufficiently large value on CSR relative to the private good itself. Otherwise, consumers are better off consuming the private good with no CSR content.

Since engaging in CSR always increases the firm's profits in this setup, the value of β that is required for CSR to be welfare improving in sum is lower, that is $\frac{3(\beta-1)^2}{4} + (\beta - 1) > \frac{\alpha-c}{2}$(proof in the appendix). It should be noted here that CSR being welfare improving does not prevent the possibility of it being a means of redistribution of surplus from the consumers to the producer[7] due to the prime the monopolist charges on

[6]This result relies on the assumption that both the public and private components of the good are substitutes in consumption.

[7]This is the case when the value of β is such that CSR improves total welfare but not consumer surplus.

consumers' contributions to the public good through CSR. Hence, unless the monopolist has a comparative advantage in providing this particular public good, this is perhaps not the most efficient means for the private provision of public goods.

4 Regulated Scenario

This section considers a three-stage game where a regulator first sets a tax. The firm then decides whether or not he will engage in CSR activities and chooses the CSR-price bundle as to maximize its profits. Each consumer, given his θ_i, forms his demand taking into account the tax rate set by the government and the price and per unit contributions set by the producer. Finally, the regulator uses the collected taxes to provide a certain amount of the public good, which can complement or substitute for the firm's CSR investment.

4.1 Second-stage outcome

Ad valorem tax The game will be solved backwards. The point of departure is thus the subgame played by the firm and consumers in the final stage after the government has decided on the tax rate to be imposed. Introducing ad valorem taxation at the rate t, consumer i chooses to purchase the product whenever $\Delta u_i(t) = \Delta u_{i1}(t) - \Delta u_{i0}(t) = \beta s - \frac{1}{2}(1-\theta_i)s^2 + r(s,p) + \alpha - (t+1)p \geq 0$. The monpolist's demand for its product is given by $Q(t) = \frac{2[\beta s(t) - (t+1)p(t) + \alpha]}{s^2(t)+1}$. The choice of the CSR-price bundle is given in the following proposition.

Proposition 4. *Given an ad-valorem tax, t, the firm chooses the bundle*

$$(s^t, p^t) = \left[\frac{\beta - (t+1)}{\alpha - (t+1)c}, \frac{\beta^2 - (t+1)^2 + \alpha^2 - (t+1)^2c^2}{2(t+1)[\alpha - c(t+1)]}\right]$$

if $\beta > t+1$ and $\alpha > c(t+1)$, and $(s_0^t, p_0^t) = (0, \frac{\alpha + c(t+1)}{2(t+1)})$ otherwise.

This proposition states that the firm will engage in CSR only if $\beta > t+1$ and $\alpha > c(t+1)$;[8] that is, CSR is feasible only if the marginal willingness to pay for CSR activities covers the *augmented* marginal cost of CSR and the marginal willingness to pay for the private good exceeds the taxed marginal cost of production. If the above conditions hold, the increase in firm's profits due to the higher price it can set for its CSR-private good bundle overcomes the increase in firm's costs due to CSR effort and taxes - compared to the regulated case without CSR activities - and therefore, the firm has an incentive to provide a positive level of CSR when complying to the tax rate set by the government. Otherwise, the firm will have no incentive to engage in CSR, it will

[8] We refer the reader to the proof of proposition 1 given in the appendix to verify that s^t and p^t given in the above proposition yield a maximum under these conditions.

pay the taxes imposed by the regulator and produce only the private good, provided $\alpha > c(t+1)$. The equilibrium under an ad valorem tax is characterized by

$$\begin{aligned} Q^t =& \alpha - c(t+1) \\ S^t =& \beta - (t+1) \\ \pi^t =& \frac{[\beta - (t+1)]^2 + [\alpha - c(t+1)]^2}{2(t+1)} \end{aligned} \tag{5}$$

An ad valorem tax thus narrows the pool of consumers purchasing the good, reduces aggregate CSR investments of the firm as well as its profits.

Specific tax Now consider the case where the regulator sets a specific tax on consumption, τ. The monopolist's demand for its product is given by $Q(\tau) = 1 - \hat{\theta}(t)$ where $\hat{\theta}(t)$ solves $\Delta u_i(\tau) = \beta s - \frac{1}{2}(1-\theta_i)s^2 + r(s,p) + \alpha - p - \tau \geq 0$, i.e. $\hat{\theta}(\tau) = 1 - \frac{2(\beta s - p - \tau - \alpha)}{s^2+1}$. The following proposition presents the firm's optimal choice.

Proposition 5. *Given a specific tax, τ, the firm's optimal choice is*

$$(s^\tau, p^\tau) = \left[\frac{\beta - 1}{\alpha - \tau - c}, \frac{\beta^2 - 1 + (\alpha - \tau)^2 - c^2}{2(\alpha - (c + \tau)}\right]$$

if $\beta > 1$ and $\alpha > c + \tau$, and $(s_0^\tau, p_0^\tau) = (0, \frac{\alpha + c(t+1)}{2(t+1)})$ otherwise.

The equilibrium quantity, firm's total CSR investments and profits turn out to be

$$\begin{aligned} Q^\tau =& \alpha - (c + \tau) \\ S^\tau =& \beta - 1 \\ \pi^\tau =& \frac{(\beta - 1)^2 + (\alpha - (c + \tau))^2}{2} \end{aligned} \tag{6}$$

A specific tax narrows the pool of consumers purchasing the good without hampering the firm's private investment in the public good provision. In that sense, This result is consistent with the findings of the literature on the comparative effects of ad valorem and specific taxes (Kay and Keen, 1983) if one considers CSR as product quality and/or variety. Finally, note that a specific tax results in reduced profits for the firm.

Before we plug the results obtained into stage 1 of the game where the regulator decides on the tax rate to impose, we analyze how consumers and the firm react to an ad valorem tax versus a specific one.

4.2 Ad valorem tax versus Specific tax

For this part of the analysis, we consider both t and τ to be exogenous and compare the way in which each affects the key endogenous variables of the model, namely the price, CSR content of the product, aggregate output, total CSR investment and firm's profits.

Consider the *pricing rules* obtained from the monopolist's maximization problem under ad valorem and specific taxation respectively:

$$p^t = \frac{\beta + (t+1)}{2(t+1)} s^t + \frac{\alpha + c(t+1)}{2(t+1)} \tag{7}$$
$$p^\tau = \frac{\beta + 1}{2} s^\tau + \frac{\alpha - (c+\tau)}{2}$$

with the coefficient of s, in the first term, and the second term being respecively the premium charged for CSR and the part of the price imputed to the private good. The monopolist sets his price as a markup on both the CSR content of the product and his marginal cost of production. While an ad valorem tax reduces the markup on both costs, a specific tax only reduces the markup on the private good production. That is, the firm's ability to charge a high price for its product is reduced. The price it is able to charge for the CSR content of this product however remains unaffected by the specific tax.

A priori, one would expect the increase in the tax rate to decrease the CSR effort of the producer who now incurs higher costs. We find however that imposing a tax does not necessarily have a repressive effect on the *CSR content of the product.*

Lemma 6. *While a specific tax* always *results in increased per unit CSR contributions, an ad valorem tax increases the CSR content of the product iff* $\frac{\beta}{1} > \frac{\alpha}{c}$ *, and decreases it otherwise.*

As indicated, the optimal choice of CSR content of the product in our model is equal to the marginal profitability of CSR activities relative to that of the private good, under the assumption that they are substitutes in consumption. When the regulator introduces a consumption tax, he reduces the marginal profitabilities of both goods but not necessarily proportionally.[9] The tax then affects not only the absolute, but also the relative profitabilities, which in turn affects the firm's choice of CSR level. Only if CSR is *sufficiently* more profitable will the increase in tax induce the producer to increase his CSR activities to compensate for his lower returns from selling the private good. This can be seen as the monopolist operating on two separate markets, and taxes make him redistribute his businesses according to the relative profitability of each. Now unlike the ad valorem tax that is perceived as a proportional increase in the marginal costs of both the firm's activities, namley CSR and the private good production, the specific tax is seen as an increase in the marginal cost of the private good production. Consequently, the firm always increases the CSR content of its product as a response to the specific tax[10] since the relative profitability of this activity *always* increases. It should be noted however that, whether per unit CSR increases or decreases, total CSR contributions always decrease in the ad valorem tax and remain unchanged under specific taxation as

[9]While the average marginal profitability of CSR ($\beta - (t+1)$) decreases by dt, that of the private good ($\alpha - c(t+1)$) decreases by cdt.

[10]Note that $\frac{ds^\tau}{d\tau} = \frac{\beta - 1}{\alpha - c - \tau}$ which is always positive.

can be seen from (5) and (6).

Under both forms of taxation, the *pool of green consumers* always narrows, at equilibrium, as the tax increases. This result is driven by the *prestige* component in the utility function of consumers: even if after a tax increase consumers with lower θ find the product more appealing (higher CSR content) or more affordable (lower price), they will be dissuaded from purchasing the good due to the lower prestige utility that results from everyone buying the good. Hence, by the means of the tax rate, the regulator can actually determine the pool of green consumers since. This also explains why the aggregate demand always decreases in the tax rate, as can be seen from (5) and (6), regardless of the monopolist's choice of the CSR content and the market price.

Thus, compared with a situation without regulation, both an ad valorem tax and a specific tax result in a narrower pool of consumers purchasing the good. While an ad valorem tax reduces the firm's profits from both activities, a specific tax reduces only the profits on the private component of the good. Finally, an ad valorem tax reduces the firm's total investment in CSR, whereas a specific tax does not affect it. This analysis suggests that if the regulator thinks the level of private investment is about right in the no-tax equilibrium but wishes to raise some revenue then it would be reasonable to impose a specific tax. Conversely, if the CSR investment is unnecessarily high, he can reduce it by setting an ad valorem tax. In that sense, the ad valorem tax has a *corrective* function whereas the specific tax has a *redistributive* one.

5 Optimal Tax structure

Now we turn to stage one of the taxation game where the regulator decides on the tax to be imposed given the behavior of the different agents in the economy.

There is a single welfare-maximizing regulator, raising revenue only through taxes on products. Let the tax revenues be G^k where $k \in \{t, \tau\}$ denotes the cases where an ad valorem tax method and specific taxation are adopted respectively, such that

$$\begin{aligned} G^t &= tp^t Q^t \\ G^\tau &= \tau Q^\tau \end{aligned}$$

Tax revenues are meant for public good provision in order to benefit consumers. Unlike the unregulated scenario where the overall level of public good in the economy, Y, coincides with the total monopolist CSR investment, after the government intervention it becomes

$$Y^k = Y(G^k, S^k)$$

The exact functional form depends on the production technology of the public good. Precisely, two scenarios are considered. In the first, the private and public investment in the public good are substitutes, and in the second, they are complements. While a simple additive production function helps illustrate the former $Y^k_{sub} = G^k + S^k$, the latter is represented by the function $Y^k_{comp} = G^k S^k$.

The regulator thus chooses the tax t_j or $\tau_j$where $j \in \{sub, comp\}$ denotes the production technology of the public good, such that

$$t_j = \underset{t \in \mathcal{R}}{\operatorname{argmax}} CS_j(t) + \pi^t$$

and

$$\tau_j = \underset{\tau \in \mathcal{R}}{\operatorname{argmax}} CS_j(\tau) + \pi^\tau$$

Solving for the optimal tax rate yields the following result:

Proposition 7. *A welfare -maximizing regulator optimally sets*

- *an ad valorem subsidy (negative tax rate), in the substitution case, given by*

$$t_{sub} = -\frac{\beta + 1}{2c^2 + 1}$$

- *in the Complementarity case:*
  - *a positive ad valorem tax rate $t_{comp} > 0$ under the sufficient - but not necessary - condition*

$$c^2 < \frac{(3\beta - 4)(\alpha^2 + \beta^2)}{2} - 1$$

  - *or a specific tax $\tau_{comp} = \frac{(\alpha - c)(\beta - 2)}{2\beta - 3}$ which is negative (a subsidy) if $0 < \beta < 2$, null if $\beta = 2$ and positive if $\beta > 2$. (proof in the appendix)*

Substitution case Under ad valorem taxation, both consumers' surplus from the private good and the monopolist's profits always decrease in the (positive) tax rate: it both narrows the pool of consumers purchasing the good, and thus excludes some consumers from the market, *and* weighs negatively on the price, so the monopolist has disincentives to contribute to the public good. Furthermore, the amount of purchases that are being taxed decreases which weighs negatively on the tax revenues and hence on the government provision of the public good. When the public and private provision are substitutes, the surplus resulting from the overall level of public good is then insufficient to compensate for the firm's and consumers' loss. By imposing a positive tax, the regulator would be crowding-out the firm's CSR investment without creating sufficient resources to replace it. This suggests that a good public policy would be to subsidize the firm's product rather than tax it. In that case, the regulator would be shifting the public good provision to the firm, while reducing the price and thus preventing the exclusion of consumers from the purchase of the private good. The optimal specific tax in this scenario is null since it does not affect the firm's CSR investment, so the subsidy would simply boost the private good market at the expense of the public good provision and the surplus from both the warm glow and prestige. An ad valorem subsidy is welfare superior to a specific tax or subsidy in the substitution case.

β	t_{comp}	W^t_{comp}	τ_{comp}	W^τ_{comp}
1.3	-0.463	2.6353	3.5	0.3825
1.5	-0.311	2.4874	-	-
1.6	-0.254	2.4793	-1.999	3.8699
2	-0.058	2.7652	0	2.75
2.2	0.018	3.0817	0.286	3.1371
2.5	0.115	3.7768	0.5	3.9375
2.8	0.305	4.7184	0.615	4.9223
3	0.296	5.592	0.667	5.6667
5	0.7383	24.8654	0.857	16.5714
6.5	1.045	58.6766	0.9	28.7375

Figure 1: The impact of varying β (with $\alpha = 2$ and $c = 0$) on the optimal tax structure. The rows in blue correspond to the case where an ad valorem tax is welfare superior. The rows in green correspond to cases where the specific tax dominates.

β	t_{comp}	W^t_{comp}	τ_{comp}	W^τ_{comp}
1.5	-0.286	0.9218	-	-
1.6	-0.225	0.9357	-1.999	1.1699
1.8	-0.142	1.0493	-0.333	1.0133
2	-0.099	1.2572	0	1.25
2.2	0.013	1.5802	0.143	1.5943
2.5	0.105	2.2470	0.25	2.25
2.8	0.172	3.1720	0.308	3.0531
3	0.226	3.9487	0.333	3.6667
5	0.639	21.7901	0.429	13.1428
6.5	0.888	53.3846	0.45	24.2

Figure 2: The impact of varying β (with $\alpha = 2$ and $c = 1$) on the optimal tax structure. The rows in blue correspond to the case where an ad valorem tax is welfare superior. The rows in green correspond to cases where the specific tax dominates.

Complementarity case In contrast, when both forms of investments in the public good are complements, a benevolent regulator could optimally intervene on the market, under certain conditions, by setting a positive ad valorem tax that allows it to finance a certain level of public investment that is necessary for the firm's CSR investments to be productive, that is, for the resulting public good to be sufficiently large to offset the loss in welfare. The sufficient condition for a positive tax to be imposed in this case is that the producer is *relatively efficient* in the private good production. Intuitively, when the producer's profit margin is sufficiently large, the regulator can extract tax revenues to finance the public investment without hampering CSR activities and without causing a sharp decrease in both the firm's profits and the consumers' surplus as the exclusion of buyers is minimal under an efficient producer (see equation 5).[11]

Recall that both marginal willingness to pay for the private and for the public components of the good have a positive effect on the price and hence on the monoplist's profits. Further, as the price increases, the proceeds from taxation increase and can be reinjected in the form of government provision of the public good which complements the CSR investments in this case and benefits both the responsible and irresponsible consumers. A positive ad valorem tax is welfare-improving when producers can afford a squeeze on the margin. However, a subsidy is required when this condition is not met (see Tables 1 and 2).

There are three subcases in the complementarity scenario under specific taxation. First, when the average sensitivity to CSR, as captured by β, is too low, the private provision of public good, prior to the intervention, is quite low. Since specific taxation cannot enhance the private investment, and hence the overall level of public good due to the complementarity. The the regulator then ought to subsidize the producer so as to expand the pool of consumers purchasing the good and enhance the producer's profits from sales of the private good. Second, when β is relatively large, a positive specific tax should rather be imposed to generate revenues to boost the public good provision which can then increase the overall public good without hampering the private investment. Third, when β has an intermediate value,[12] no intervention is required.

Consider the choice between an ad valorem and a specific tax. Although no formal mathematical condition could be derived, the intuition behind this choice is presented. The desirability of a specific tax depends on two questions: *is the level of private investment prior to the intervention about right? Will a squeeze on the producer's margin from the private good sales generate enough revenues?* If the answer to both questions is positive, then it is likely that intervention through specific tax dominates ad valorem taxation. As can be seen from Tables 5 and 6, for relatively low values of β, i.e. $\beta \leq 2$, an ad valorem subsidy dominates specific subsidy. Intuitively, when β is small, the initial CSR investment is quite low. A specific subsidy, at best, increases welfare on the private good market as explained above. An ad valorem subsidy however has a corrective

[11] In fact, as illustrated in Tables 1 and 2, the socially optimal tax rate increases in any factor that enhances the firm's profit margin. A higher tax rate is required the higher the social consciousness of consumers, β and the larger their propensity to pay and the lower the production costs.

[12] That is, $\beta = 2$, given the particular assumptions and parameters of the model.

function as it boosts the private provision by increasing the firms' profits at the expense of a reduced consumers' surplus due to the lower prestige from buying the good. Ad valorem subsidy dominates a specific one over this range of values.
When β is high but not excessively so,[13] the level of private investment prior to intervention is about right, a specific tax here then serves the distributive function; it generates revenues to finance the public investment necessary to complement CSR while keeping CSR at its initial level.[14] Specific taxation then dominates ad valorem taxation which would reduce the CSR investment and reduce the firm's profits from both activities without generating sufficiently large revenues for government provision since the profit margin on CSR was not initially high.
Finally, for large values of β,[15] the CSR investment prior to intervention is found to be unnecessarily high and hence an ad valorem tax that extracts from the profit margin on CSR to fuel the public provision is welfare superior.

6 Conclusion

This paper shows how regulator's decision to exempt CSR firms from taxes should depend on the nature of the CSR investment when consumers experience both a warm glow and prestige benefit from buying ethical products. While CSR investments are typically considered and analyzed as a welfare-improving variable that needs to be promoted, our results indicate the need for CSR efforts to be integrated within the broader framework of public good provision in the economy. Incentives offered to CSR firms need to be adjusted to market characteristics (e.g., consumer heterogneity and willingness to pay) and nature of interdependence with the public provision of public goods (namely whether both forms of investment are substitutes or complements) to maximize returns.

We show that while tax exemptions are always welfare improving when the CSR investment susbstitutes for the government provision of the public good, taxing the product with a public add-on can be optimal in the complementarity case. Furthermore, while an ad valorem subsidy is welfare superior to a specific one, a specific tax dominates ad valorem taxation at times. When private and public investments in the public good are substitutes, subsidizing CSR amounts to higher profits for the firm, a larger CSR investment at the expense of a lower distinction utility for consumers. Whereas in the case of complement investments, if the social interest in CSR is sufficiently large, private goods with a public component should be taxed, precisely, a specific tax is preferred since, while leaving the firm's total CSR investment unaffected, it generates revenues to fund the government provision of the public good so as to increase both the buyers and non-buyers' surplus. In that sense, a specific tax is seen as having a *redistribution* function as it enhances consumers welfare at the expense of reduced profits for the monopoly while increasing total welfare in the process.

[13] See the rows in green in tables 1 and 2.

[14] Note that the value of the optimal specific tax in this case decreases as the willingness to pay for the private good, α, and hence the profit margin from sales of the private good, increases.

[15] This part refers to the bottom rows in red in tables 1 and 2.

When consumers are quite highly interested in CSR activities, the regulator ought to impose an ad valorem tax on the CSR product. The ad valorem tax is then serves as a *corrective* device as it reduces the firm's CSR investment, that is deemed to be unnecessarily high in this case, to allow for an increase in the government provision and, consequently, in the overall level of public good available. Only when the social consciousness of consumers, as represented by their willingness to pay for CSR, is sufficiently low, will the regulator optimally intervene by introducing an ad valorem subsidy which aims at correcting the private-public shares in the public good provision.
In sum, our analysis suggests that, an economy where consumers have, on average, a high demand for firms to engage in CSR and value the private good to which CSR investments are linked, would benefit from government intervention through taxation. In that particular case, taxing CSR products *is* welfare improving and can serve as a *means of progressive taxation*, whereby more taxes are levied on wealthier consumers - if one admits the degree of altruism to be positively related to income - to make the public good available to everyone. Provided that the proceeds from taxation are used to enhance the productivity of such investments, taxing CSR in this case is said to yield a *double dividend*, namely the higher level of public good and the additional redistributional benefit that the tax enables.

Our research also has several limitations. We have considered a constant cost for CSR activities that is separable from the standard production cost. It is likely that the supply curve is upward sloping, for example, when the public good in question is the reduction of environmental impact from a natural resource in finite supply. Further, relaxing the assumption about additive separability of private good and the public add-on in consumers' utility function may also offer some new insights. Moreover, due to the uniform distribution assumption together with the existence of the prestige utility, it was not possible to examine the possibility of CSR being used as a vertical differentiation device or to examine the case of a duopoly with one of the firms offering the pure private good separately. Since CSR are typically communicated by firms engaging in CSR, it remains questionable whether these activities meet the high levels as claimed. The moral hazard problem between the firm and consumers about CSR may be an interesting area of research.

7 Appendix

Proof of Proposition 1

Proof. • From the first derivative $\frac{\partial \pi(s,p)}{\partial p}$, we obtain that $p^*(s) = \frac{\beta+1}{2}s + \frac{\alpha+c}{2}$. Setting $\frac{\partial \pi(s,p)}{\partial s} = 0$ and substituting for $p^*(s)$ yields $s^* = \frac{\beta-1}{\alpha-c}$ that we plug into the foc with respect to p to obtain the optimal price p^*. Checking the second-order conditions:

$$\pi_{pp}|_{s^*,p^*} = -\frac{4(\alpha-c)^2}{[(\alpha-c)^2+(\beta-1)^2]} < 0$$

$$\pi_{ss}|_{s^*,p^*} = -\frac{(\alpha-c)^2[(\alpha-c)^2+(\beta+1)^2]}{(\alpha-c)^2+(\beta-1)^2} < 0$$

$$\pi_{ps}|_{s^*,p^*} = \frac{2(\beta+1)(\alpha-c)^2}{(\alpha-c)^2+(\beta-1)^2}$$

The determinant of the corresponding Hessian matrix is then

$$D|_{s^*,p^*} = \frac{4(\alpha-c)^6}{[(\alpha-c)^2+(\beta-1)^2]^2} > 0$$

Hence (s^*, p^*) is clearly a maximum. Another value that obtains from the FOCs is $s = \frac{\alpha-c}{1-\beta}$, however it is a saddle point as the determinant of the corresponding Hessian matrix is equal to $-\frac{4(\beta-1)^6}{[(\alpha-c)^2+(\beta-1)^2]^2}$ which is always negative.

• For s to be positive, it has to be that $\alpha > c$ *and* $\beta > 1$. To see this, we substitute the optimal values into the aggregate demand which yields $Q^* = \alpha - c$, which is positive only if $\alpha > c$; and hence $s^* = \frac{\beta-1}{\alpha-c} > 0$ only if $\beta > 1$ as well.
If $\alpha > c$ but $\beta < 1$, the monopolist abstains from CSR and sets the price so as to maximize $\pi(p) = 2(p-c)(\alpha-p)$ which yields $p^*|_{s=0} = \frac{\alpha+c}{2}$.

□

Proof of Lemma 3

Proof. In the absence of CSR activities, consumers' surplus is simply given by $CS^0 = \int_0^1 \alpha - pf(\theta)d\theta + Y = \frac{\alpha-c}{2} + 0$, assuming in this scenario that the overall level of public good is null since there is no government intervvention. In the CSR case, total consumer surplus is

$$CS(s,p) = \int_{\theta=0}^{1} [\beta s - (1-\theta)\frac{s^2}{2} + \frac{\theta^*(s,p)-1}{2} + \alpha - p + Y]f(\theta)d\theta$$

Substituting for the value of $p^*(s)$ given by (5):

$$\begin{aligned} CS(s^*,p^*) =& [\frac{\beta-1}{2}s - \frac{s^2}{2}]\int_{\theta^*}^{1} f(\theta)d\theta + \frac{s^2}{2}\int_{\theta^*}^{1}\theta f(\theta)d\theta + Y = \frac{(\beta-1)^2}{4} + Y \\ =& [\frac{\beta-1}{2}s - \frac{s^2}{2}](1-\theta^*) + \frac{s^2}{2}(\frac{1}{2} - \frac{(\theta^*)^2}{2}) + Y \end{aligned}$$

Finally plugging in the equilibrium value of θ^* and using the relation $Y = sQ = \beta - 1$, this expression reduces to:

$$CS(s^*,p^*) = \frac{(\beta-1)^2}{4} + \beta - 1$$

Total welfare in the benchmark model with CSR activities is thus greater than in the absence of CSR iff:

$$\pi(s^*,p^*) + CS(s^*,p^*) > \pi^0 + CS^0$$

$$\frac{(\beta-1)^2}{2}+\frac{(\beta-1)^2}{4}+(\beta-1)>\frac{\alpha-c}{2}$$

Solving the above inequality for $(\beta-1)$ yields $W(s^*,p^*)>W^0$ if $(\beta-1)<-\frac{\sqrt{2}\sqrt{3(\alpha-c)+2}+2}{3}$ - which is always negative and hence there are no CSR activities in this case - or $(\beta-1)>\frac{\sqrt{2}\sqrt{3(\alpha-c)+2}-2}{3}$. □

Proof of Proposition 7

Proof. • The optimal value of t_{sub} is obtained from the first-order condition. It is always a maximum as the second derivative yields

$$-\frac{2c^2+1}{2}<0$$

• Let $x=(t+1)$, the optimal value t_{comp} that maximizes welfare in the complementarity scenario solves the first order condition given by:

$$3(c^2+1)x^4-[(2\beta+1)(c^2+1)+c^2]x^3+[(c^2+1)-(\beta^2+\alpha^2)+\beta c^2]x^2+(\beta^2+\alpha^2)(\beta-1)=0$$

Since $\frac{dW}{d_t}=0$ at the optimum, the second order condition can be written as:

$$\frac{dW^2}{d^2t}=\frac{dW^2}{d^2t}-\frac{dW}{d_t}<0$$

which gives the condition for a maximum:

$$(3t^4+12t^3+17t^2+10t+2)(1+c^2)+(t^2+2t+4)(\alpha^2+\beta^2)<\beta c^2(2t+1)+3\beta(\alpha^2+\beta^2) \quad (8)$$

with both the LHS and the RHS of the above inequality being strictly increasing functions in t. If the slope of the LHS(t) is greater than that of RHS(t), a sufficient condition for the above inequality to hold, for positive values of t, is that, at $t=0$, the curve representing the LHS(t) be below that of the RHS(t). Setting $LHS(0)=RHS(0)$ we obtain

$$2(c^2+1)+(4-3\beta)(\alpha^2+\beta^2)<\beta c^2$$

that we rearrange to obtain the condition in the proposition. This condition is however unnecessary if $LHS'(t)<RHS'(t)$ in (21).

□

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