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The political economy of the vote with the wallet

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Abstract

The willingness to pay of private consumers for socially and environmentally responsible companies retailing public goods is an emerging though under-researched contemporary economic feature. We model the problem faced by responsible consumers as a typical multiplayer prisoner's dilemma and analyse four redistribution mechanisms that can be implemented by regulators and institutions to enforce the cooperative equilibrium. The desirable property of three of these schemes is that of extending the parametric interval of cooperative equilibrium without additional government expenditure. We also discuss the implication of our results for already implemented policies such as feed-in tariffs (FITs).

Keywords: Redistribution mechanism, Corporate social responsibility, Multiplayer prisoner's dilemma.

JEL Classification: C72 (Noncooperative Games), D71 (Social choice), M14 (Social Responsibility).

I Introduction

Corporate social responsibility (CSR) of companies selling bundles of private and public goods and willingness to pay for social and environmentally responsible features of goods and services by concerned consumers who "vote with the wallet" are phenomena of growing relevance in global markets.[1] These grassroots economic initiatives are particularly

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[1] In 2011, CSR reporting involved 95 percent of the 250 largest companies in the world (KPMG, 2011). In the *2014 Nielsen Survey on Globally Conscious Consumers* 55 percent of respondents from different continents declared to be willing to pay an extra price for the socially and environmentally responsible features of products, a share 10 percent higher than in the 2011 survey. For recent surveys on CSR see Kitzmueller and Shimshack (2012), Hoi et al. (2013).

interesting in terms of welfare effects, especially in times of shirking budget constraints due to high public debts. In this paper we model the vote with the wallet game as a multiplayer prisoner's dilemma (PD) and discuss optimal mechanism designs which allow regulators and institutions to exploit this bottom-up resource (i.e., the willingness to pay for public goods from concerned consumers) to address negative externalities and provide public goods.

The growing relevance of the vote with the wallet phenomenon is supported by statistics on the growth of Environmental, Social and Governance (ESG) Economics and, more specifically, of socially responsible (SR) investment funds, on the investor side, and Fairtrade products, on the consumer side. In the first case, investment funds "voting with the wallet" by using exclusion criteria grew by 91 percent between 2011 and 2013 in Europe and ended up covering an estimated 41 percent (€6.9 trillion) of European professionally managed assets (Eurosif, 2014). In the United States, the US SIF report finds that Sustainable, Responsible and impact Investing (SRI) assets expanded by 76 percent in two years from $3.74 trillion in 2012 to $6.57 trillion in 2014, thereby reaching more than one sixth of the market (US SIF, 2014). A novel initiative confirming the increasing role of SR funds is the Montréal Carbon Pledge which gathers $3 trillion of assets under management. The initiative, coordinated by the UN-supported Principles for Responsible Investment, requires that signatories "commit to measure and publicly disclose the carbon footprint of their investment portfolios on an annual basis".[2] Some of these funds are starting to take commitments to reduce their footprint on yearly basis thereby providing a new field of application of the vote with the wallet.

On the consumer side, one of the most well-known examples of ESG Economics is represented by Fairtrade products.[3] In recent years, Fairtrade sales have grown considerably more than aggregate consumption in most high-income countries. In particular, in 2012 Fairtrade sales registered a 33 percent yearly growth in Germany, 28 percent in Sweden, 26 percent in The Netherlands, 25 percent in Switzerland, and 16 percent in the UK. The 2013-14 Fairtrade Annual Impact Report documents that, in 2013, 31 percent shoppers seeked fairtrade products, while 77 percent know the fairtrade trademark (Fairtrade Foundation, 2014). A valuable effect of Fairtrade diffusion has been that of triggering partial imitation on behalf of profit maximizing incumbents (Becchetti and Solferino, 2011). Examples of it are Nestlé,[4] Tesco, Sainsbury, Ben & Jerry (Unilever),[5]

[2]Montréal Pledge, 2014. Retrieved from http://montrealpledge.org.

[3]Fairtrade products are food and textile products sold with the Fairtrade Labelling Organizations (FLO) label indicating to consumers the socially and environmentally responsible characteristics of their product chain. According to the World Fair Trade Organization (WFTO) definition (2009), "Fair Trade is a trading partnership, based on dialogue, transparency and respect, that seeks greater equity in international trade. It contributes to sustainable development by offering better trading conditions".

[4]Wason, E. (2005, October 7th), "Nestle introduces fairtrade coffee, eco-friendly product goes mainstream", *Mongabay.com*. Retrieved from http://news.mongabay.com/2005/1007-reuters.html.

[5]Gunther, S. (2010, October 25th), "Ben & Jerry announces big move into fair trade", *Mother Nature Network*. Retrieved from http://www.mnn.com/earth-matters/wilderness-resources/blogs/ben-jerry-announces-big-move-into-fair-trade.

Starbucks, Mars,[6] and Ferrero.[7] A recent Boston Consulting Group Report documents that "responsible consumption" (RC) products account for at least 15 percent of all grocery sales, that is estimated around $400 billion of total current annual grocery sales (Smits et al., 2014).

Statistics provided above document that millions of consumers and investors buy and invest responsibly, and that an even larger number faces everyday the choice between standard and ESG-augmented products (if we reasonably assume that some of those who are faced with such a choice do not choose the ESG-augmented products).

In our model we sketch the dilemma inherent to the choice between standard and SR products in what we define the *vote with the wallet game*. The vote with the wallet game is designed as a multiplayer prisoner's dilemma in which players' utility is affected by the following three parameters: i) the positive externality produced by the more responsible stance of companies, which is proportional to the share of responsible consumers voting with the wallet; ii) the players' other-regarding preference component (if any), which is the enjoyment of the consumer arising when she vote responsibly; iii) the cost differential between the ESG-augmented product and the standard product.

In the above framework, one fundamental issue is how the government can implement a redistribution mechanism aimed at exploiting this grassroots potential, in order to provide public goods and address negative social and environmental externalities. In our paper we investigate this problem and study the effectiveness of different redistribution mechanisms. We start from the basic theoretical framework developed by Becchetti and Salustri (2015), and we analyse whether the prisoner's dilemma can be solved by redistribution mechanisms that make the government able to transfer, ex post, a share of the payoffs from "defectors" (i.e., conventional product buyers) to "cooperators" (i.e., responsible product buyers). More specifically, we examine four different mechanisms. The first makes the government able to redistribute a portion of the defectors gain to cooperators. In second, the government taxes defectors for a portion of the extra-costs paid by cooperators, and equally redistribute the the tax return to cooperators. The third makes the government able to levy a lump-sum tax on each defector and equally redistribute the total tax return to each cooperator. In the fourth the government subsidises responsible product buyers drawing resources from conventional product buyers. The relevant common properties of these redistribution mechanisms are those of expanding the parametric interval of cooperative equilibrium without extra costs for the government (with the exception of the fourth in one specific case).

Solutions to the prisoner's dilemma and, more generally, to social dilemma have been analysed from different approaches. From a game theory perspective, it is widely debated whether an external Leviathan intervention, such as taxes set by the government, is "the only way" to solve a social dilemma. Along this line, Ostrom (2000) argues that proposing a new set of rules causes a new collective dilemma among principals, as the

[6] Mars (2011, September), "Mars and Fairtrade International announce collaboration". Retrieved from http://www.mars.com/global/press-center/press-list/news-releases.aspx?SiteId=94&Id=3182.

[7] Nieburg, O. (2014, March 20th), "Ferrero makes Fairtrade cocoa commitment after rule change", *Confectionery news*. Retrieved from http://www.confectionerynews.com/Commodities/Ferrero-makes-Fairtrade-cocoa-commitment-after-rule-change.

new set of rules can be considered itself as another public good. With regards to CSR, Besley and Ghatak (2007) prove that firms adopting CSR will produce the same level of public good as predicted by standard private provision equilibrium, and therefore below the first-best level. However, under the assumption that the government is efficient, public provision may reach the first best Samuelson-Lindahl equilibrium. Accordingly, Bergstrom et al. (1986) show that in a general model of non-cooperative provision of public goods, a larger redistribution of wealth will change the set of contributors and thereby the equilibrium provision of the public good.

This paper deals with redistribution mechanisms that the government can implement in the vote with the wallet game setting, in order to allow people to vote responsibly, thereby solving the inefficiency related to the prisoner's dilemma, and ultimately boosting firms to adopt more socially and environmentally sustainable policies. Our theoretical analysis provides relevant insights for policymakers since some of the redistribution mechanisms under theoretical scrutiny are actually at work in many countries. Any time a government subsidises the purchase of a socially and environmentally responsible good or service (e.g., tax allowances on renewable energy choices, house restructuring, or companies selling Fairtrade products), and does it on a balanced budget basis, it is actually redistributing away from defectors (e.g., taxpayers choosing the conventional product) to cooperators (e.g., consumers choosing the sustainable product). In order to link our theoretical results to the experiences observed in the reality, we discuss how our four redistribution mechanisms can provide suggestions for the implementation of already operating policies such as feed-in tariffs – adopted in 63 jurisdictions around the world to provide incentives for renewable energy adoption (Couture and Gagnon, 2010) – and similar redistribution mechanisms that could be generated in the future.

The paper is divided into five sections (including introduction and conclusion). In the second section we outline the basic features of the vote with the wallet game as a hybrid provision multiplayer prisoner's dilemma. In the third section we study the redistribution designs that policymakers may implement to exploit the willingness to pay of responsible consumers and investors. The fourth section deals with policy implications and applications of our model. The fifth section concludes.

II The model

As formalized by Becchetti and Salustri (2015), in the simplest (two-player) vote with the wallet game, two players, *player 1* and *player 2*, can choose between two strategies, *voting the responsible* (VR) or *vote for the conventional* (VC) product (we also refer to VR and VC as *vote responsibly* and *vote conventionally*, respectively). From now on, we use indistinctly the term *voter* and *buyer*, to stress the fact that each purchase can be viewed as a vote that rewards one product or another.

The i-th player's payoff, for $i = 1, 2$, is given by

$$U^i(S) = \begin{cases} b + a - c & \text{if } S = (VR, VR) \\ \frac{1}{2}b + a - c & \text{if } S = (VR, VC) \\ \frac{1}{2}b & \text{if } S = (VC, VR) \\ 0 & \text{if } S = (VC, VC) \end{cases}$$

where $S := (S^i, S^{-i}) \in \{VR, VC\}^2$ is the strategy profile, and a, b, and c are crucial parameters of the game.

The first parameter $b \in (0, +\infty)$ is the positive externality arising from the voting choice. The externality arises on the assumption that the vote with the wallet for the responsible product (i.e., VR) pushes companies to a more socially, environmentally, and fiscally responsible stance in proportion to the share of responsible buyers ($\frac{1}{2}$ or 1 in the simplest two-player game).[8] The second parameter $a \in [0, +\infty)$ is the positive "warm glow" effect generated by the act of voting responsibly which arises in case of players' nonzero other-regarding preferences.[9] The third parameter $c \in [0, +\infty)$ captures the cost differential between the cooperative strategy (responsible product purchase) and the non cooperative strategy (conventional product purchase).[10] For the sake of simplicity, we also assume that players are not income constrained.

The game is described by $G = (N, (S^i)_{i \in N}, (U^i)_{i \in N})$, where $N = \{1, 2\}$ is the set of players, $S^i = \{VR, VC\}$ is the set of citizen i's strategies, for each $i \in N$, and U^i is the payoff function for each $i \in N$. The normal-form representation of the 2-player vote with the wallet game is

		Player 2: VR	Player 2: VC
Player 1	VR	$b + a - c, b + a - c$	$\frac{1}{2}b + a - c, \frac{1}{2}b$
	VC	$\frac{1}{2}b, \frac{1}{2}b + a - c$	$0, 0$

[8]Note that we exclude the case $b \leq 0$ since without a strictly positive externality the product cannot be considered as socially or environmentally responsible.

[9]The existence of other-regarding preferences, both distribution and intention based, is documented by a huge empirical literature on Dictator Games (Andreoni and Miller, 2002), Gift Exchange Games (Fehr et al., 1993, Fehr et al., 1998), Public Good Games (Fischbacher et al., 2001, Sonnemans et al., 1999, Fehr and Gächter, 2000), Trust Games (Berg et al., 1995, Ben-Ner and Putterman, 2010), and Ultimatum Games (Güth et al., 1982, Camerer and Thaler, 1995). Also, literature on behavioural studies shows that individuals have other-regarding features in their preferences, such as positive and negative reciprocity (Rabin, 1993), inequity aversion (Fehr and Schmidt, 1999, and Bolton and Ockenfels, 2000), other-regarding preferences (Cox, 2004), social welfare preferences (Charness and Rabin, 2002), and various forms of pure and impure warm glow altruism (Andreoni, 1989 and 1990). Engel (2010) explores results from around 328 different Dictator game experiments for a total of $20,813$ observations. He finds that only around 36 percent of individuals follow Nash rationality and give zero (based on these findings, Engel rejects the null hypothesis that the dictator amount of giving is 0 with $z = 35.44, p < .0001$) and more than 50 percent give no less than 20 percent.

[10]We remark that the case $c = 0$ occurs when both the conventional and the responsible product have the same price.

The unique Nash Equilibrium (NE) of the game is (VC, VC) if $c > \frac{1}{2}b + a$ and (VR, VR) otherwise. The classical prisoner's dilemma arises for intermediate values of c. More specifically, when $\frac{1}{2}b + a < c < b + a$, the unique NE is (VC, VC), but it is Pareto dominated by the strategy pair (VR, VR), which yields higher payoffs.[11] Based on the Arce and Sandler (2005) taxonomy, the vote with the wallet game is a "hybrid" provision-PD game[12] where the classical "cooperate" and "defect" strategies correspond, respectively, to the choices of buying a responsible product and a conventional product, and the self-regarding preference argument adds a private benefit to the private cost of the cooperative strategy (which is given by the extra cost of the purchase of a responsible product).

The multiplayer version of the game is described by

$$G_n = (N, (S^i)_{i \in N}, (U^i)_{i \in N}), \tag{1}$$

where $N = \{1, \ldots, n\}$ is the set of players, $S^i = \{VR, VC\}$ is the set of player i's strategies, for each $i \in N$, and U^i is the payoff function described as

$$U^i(S^i, \sigma(S^{-i})) = \begin{cases} \frac{j+1}{n}b + a - c & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ \frac{j}{n}b & \text{if } (S^i, \sigma(S^{-i})) = (VC, j) \end{cases}$$

where $\sigma(S^{-i}) \in \{0, \ldots, n-1\}$ denotes the number of responsible buyers among the i's co-players, and $\sigma(S^{-i}) = j$ where not otherwise specified. Analogously, the unique NE for the multiplayer game is (VC, VC) if $\frac{1}{n}b + a < c$ and (VR, VR) otherwise. The parametric interval of c in which we face the prisoner's dilemma is $\left(\frac{1}{n}b + a, a + b\right)$. We call such interval *PD interval*.[13]

Note that a higher number of players makes the PD interval larger (see Becchetti and Salustri, 2015). Since global markets are characterized by a large number of consumers we conclude that the prisoner's dilemma is a crucial issue in the vote with the wallet game. Another problem of the vote with the wallet game is that the enforcement of mutual responsible voting equilibrium in infinitely repeated games does not easily pass renegotiation proofness and that the formation of coalitions of buyers may increase the value of free riding.[14] This is why the redistribution mechanisms we are going to show in next section may be very useful to overcome the prisoner's dilemma.

[11] Without loss of generality, we rule out the cases in which $c = \frac{1}{2}b + a$ and $c = b + a$, since under both the outcomes (VC, VC) and (VR, VR) are equilibria and the prisoner's dilemma does not arise.

[12] Arce and Sandler (2005) classify prisoner's dilemmas into four categories (provision, commons, altruism, selfish) according to the private/public benefits and costs to players and to the action/inaction choices related to the "cooperation" and "defect" strategies.

[13] Note that when $n = 2$ we have the simplest two-player game described above.

[14] In particular, Becchetti and Salustri (2015) show that in a (finitely repeated) game with a coalition of π^* responsible buyers with a^* other regarding preferences, the potential conventional buyers will free ride as soon as $\pi^* \geq \frac{1+\delta}{\delta}(\frac{c-a^*}{b} - 1)$, where δ is the discount rate.

III Redistribution mechanisms

We define the *repeated multiplayer vote with the wallet game*, as the game G_n repeated T times. We introduce another agent, the *government*, which chooses for each player $i \in N$ and at each stage of the game $t \in \{1, \dots, T\}$ a parameter $\theta^i(t) \in \Theta$, where Θ is a set of parameters defined as $\Theta := \{\theta^i(t) \in \mathbb{R} : \sum_{i=1}^n \theta^i(t) = 0, t = 0, \dots, T\}$. For each $i \in N$, we define θ^i the *transfer of player i*.[15]

Based on what defined above, we define the government *redistribution mechanism* F^i as that leading to the following utility function

$$F^i(S^i, \sigma(S^{-i})) := U^i(S^i, \sigma(S^{-i})) + \theta^i.$$

for each $i \in N$.

Note that the definition of Θ ensures that the mechanism is budget balanced. Once the mechanism is applied, the controlled game is described as

$$\Gamma = (G_n, \Theta, (F^i)_{i \in N}), \qquad (2)$$

and we say that a *Nash equilibrium of* Γ (NE) is a Nash equilibrium of G_n after the redistribution mechanism is applied.

The payoff in the vote with the wallet game includes economic costs and benefits derived from the environmentally and socially responsible consumption of public goods, as well as the enjoyment of other-regarding preferences. Thus, the redistribution mechanism works through taxes (subsidies) levied (provided) by the government to consumption of both private and public good components. In other words, we allow the government to tax and subsidize not only the purchase of private goods, but also the contribution (or the non contribution) to the public good component. Although defining the redistribution mechanism in the real life experience could be a difficult task (e.g., the attribution of the correct monetary value to the public good component b, the political feasibility of the tax/subsidy mechanism, or the risk of hitting consumers' budget constraints), it is advisable for the government to follow a soft touch approach looking for the minimal transfer which can ensure the mutual responsible voting equilibrium. Thus, our analysis focuses on the minimum transfer required to overcome the prisoner's dilemma in the relevant PD interval.

We propose four different rules for redistributing the aggregate consumer surplus: the *proportional free-rider gain mechanism*, the *proportional cost mechanism*, the *lump-sum tax mechanism*, and the *subsidy mechanism*.

III.1 The proportional free-rider gain mechanism

The first mechanism rule, namely the *proportional free-rider gain mechanism*, redistributes a portion of the free-riders' (i.e., conventional product buyers) gain to the re-

[15] In this analysis the parameter $\theta^i(t)$ will affect the payoffs instantaneously. For the sake of simplicity we therefore remove the time index of the parameters.

sponsible buyers. In particular, we consider that the government equally redistributes half of each free rider's gain (i.e., $\frac{1}{2}\frac{j}{n}b(n-j)$, where j is the number of responsible buyers) to each responsible buyer.

In each period $t \in \{1, \dots, T\}$, and for each player $i \in N$ adopting the strategy S^i, the transfers of the government are described by[16]

$$\theta_p^i := \theta_p^i(S^i, \sigma(S^{-i})) = \begin{cases} (n-j-1)\frac{1}{2}\frac{1}{n}b & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ -\frac{1}{2}\frac{j}{n}b & \text{if } (S^i, \sigma(S^{-i})) = (VC, j) \end{cases}$$

The mechanism is budget balanced since the government redistributes the extra-profit of the conventional buyers to the responsible buyers, proportionally to the number of responsible buyers. That is, it transfers resources among agents, from the defectors to the cooperators, with no effects on its budget constraint. More formally, if j citizens vote, we require that the transfers θ_p^i are in Θ, that is

$$\sum_{i=1}^{N} \theta_p^i = j\frac{1}{2}(n-j)\frac{1}{n}b - (n-j)\frac{1}{2}\frac{j}{n}b = 0.$$

Note that the proportional mechanism always leaves each conventional buyer with a positive payoff. Moreover, the marginal benefit for the responsible buyer is decreasing in the number of responsible buyers, that is, the higher the number of the latter, the lower the individual benefit of responsible buyers from the redistribution. As a consequence, once the mechanism is applied, the payoffs are

$$\begin{aligned} F_p^i(S^i, \sigma(S^{-i})) &= \begin{cases} \frac{j+1}{n}b + a - c + \theta_p^i & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ \frac{j}{n}b + \theta_p^i & \text{if } (S^i, \sigma(S^{-i})) = (VC, j) \end{cases} \\ &= \begin{cases} \frac{n+j+1}{2n}b + a - c & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ \frac{j}{2n}b & \text{if } (S^i, \sigma(S^{-i})) = (VC, j) \end{cases} \end{aligned} \tag{3}$$

Given (3) we can define the following proposition that characterises the conditions of mutual responsible voting as an (efficient) NE, under the proportional free-rider gain mechanism.

Proposition 1 (Proportional free-rider gain mechanism and cooperative equilibrium)**.** *Let G_n be the vote with the wallet game described in* (1) *and $\Gamma_p = (G_n, \Theta, (F_p^i)_{i\in N})$ the controlled game described in* (2)*, with F_p^i the proportional mechanism as in* (3)*.*

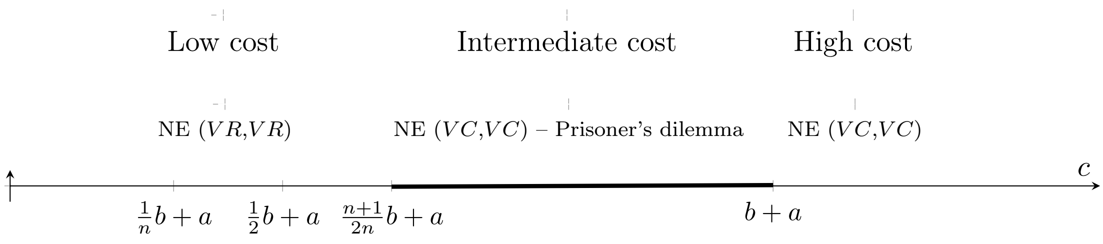
Then, mutual responsible voting is a NE of Γ_p if and only if $c \leq \frac{n+1}{2n}b + a$.

Proof. See appendix A. □

Note that, for $n \geq 2$, we have $\frac{1}{n}b+a < \frac{n+1}{2n}b+a < b+a$. Hence, the proportional redistribution mechanism reduces the PD interval by the value $\frac{n+1}{2n}b+a-\frac{1}{n}b+a = \frac{n-1}{2n}b$,

[16] Remember that if j denotes the number of player i's co-players buying the responsible product, the number of players is $j+1$ if $S^i = VR$ and j if $S^i = VC$.

Figure 1: Changes in the intervals of equilibria along the segment of c values in the multiplayer game with the proportional mechanism.



which is decreasing in n and tends to $\frac{1}{2}b$ as n goes to infinity. That is, the mechanism reduces the PD interval by (at least) $\frac{1}{2}b$.

More generally, since our goal is to find the minimal efficient transfer to enforce mutual responsible voting as a NE, we can apply the proportional mechanism making the government able to redistribute equally a generic share $q \in (0, 1]$ of the conventional buyers' benefit to each responsible buyer.[17] Accordingly, the transfers are described by

$$\theta^i_{p_q} := \theta^i_{p_q}(S^i, \sigma(S^{-i})) = \begin{cases} (n-j-1)q\frac{1}{n}b & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ -q\frac{j}{n}b & \text{if } (S^i, \sigma(S^{-i})) = (VC, j) \end{cases}$$

As previously shown, the mechanism is budget balanced since the government transfers resources among agents, from the defectors to the cooperators, with no effects on its budget constraint. Formally, if j citizens vote, we we have that θ^i_p are in Θ, that is

$$\sum_{i=1}^{N} \theta^i_p = jq(n-j)\frac{1}{n}b - (n-j)q\frac{j}{n}b = 0.$$

The balanced budget mechanism can be written as

$$\begin{aligned} F^i_{p_q}(S^i, \sigma(S^{-i})) &= \begin{cases} \frac{j+1}{n}b + a - c + \theta^i_{p_q} & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ \frac{j}{n}b + \theta^i_{p_q} & \text{if } (S^i, \sigma(S^{-i})) = (VC, j) \end{cases} \\ &= \begin{cases} \frac{nq+j(1-q)+1-q}{n}b + a - c & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ (1-q)\frac{j}{n}b & \text{if } (S^i, \sigma(S^{-i})) = (VC, j) \end{cases} \end{aligned} \tag{4}$$

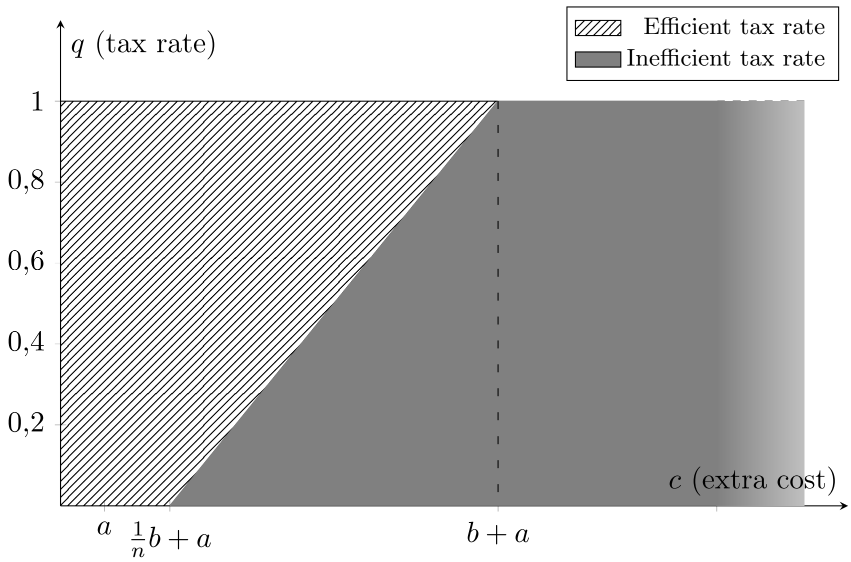
Based on what considered above, we have the following result that generalises Proposition 1.

Proposition 2 (Minimal efficient proportional free-rider gain mechanism)**.** *Let G_n be the vote with the wallet game described in* (1) *and $\Gamma_{p_q} = (G_n, \Theta, F^i_{p_q})$ the controlled game described in 2, where $F^i_{p_q}$ is the generic proportional mechanism as in* (4)*.*

Then mutual responsible voting is a NE of Γ_{p_q} if and only if $c \leq \frac{nq+1-q}{n}b + a$.

[17] We do not consider the case $q = 0$ since it corresponds to the absence of redistribution.

Figure 2: Effective tax rates and the cost of voting with the wallet (Proportional mechanism).



Proof. See appendix A. □

Proposition 2 implies that, within the PD interval (i.e., $\frac{1}{n}b + a < c < b + a$), the minimum tax rate the government can apply in order to obtain mutual responsible voting as a NE is $q = \frac{(c-a)n-b}{(n-1)b}$. Consider that, if $n > 0$ and $q \in (0, 1]$, we have $\frac{1}{n}b + a < \frac{nq+1-q}{n}b + a$. Hence, the proportional mechanism always reduces the PD interval by $\frac{n-1}{n}qb$.

Note that, in large consumer markets, the most relevant case is when $n > \frac{b}{c-a}$. Figure 2 shows the areas of efficient (white grey striped area) and inefficient (dark grey area) tax rates, that is of the tax rates which enforce mutual responsible voting as a (efficient) NE. For high values of c (i.e., $c > b + a$), none of the tax rate can enforce mutual responsible voting as a NE (the portion where $c > b + a$ is all in the dark grey area). On the other hand, for low values of c (i.e., $c \leq \frac{1}{n}b + a$) every tax rate makes mutual responsible voting efficient (the portion where $c \leq \frac{1}{n}b + a$ is all in the white grey striped area). More interestingly, for each value of c within the PD interval (i.e., $\frac{1}{n}b + a < c \leq b + a$), there is a specific minimum tax rate that makes mutual responsible voting an efficient strategy, and such minimum q is increasing in c since the higher is the cost of voting, the higher is the tax the government has to levy on the conventional buyers and redistribute to the responsible buyers.

III.2 The proportional cost mechanism

According to our second scheme, the government can apply a proportional mechanism that taxes the conventional buyers for a portion of the extra-cost c paid by the responsible buyers. This mechanism has the advantage to hinge on a publicly verifiable private cost afforded by the responsible buyers.

More specifically, the transfers of the government can be described by

$$\theta^i_{pc} := \theta^i_{pc}(S^i, \sigma(S^{-i})) = \begin{cases} \frac{n-j-1}{j+1} qc & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ -qc & \text{if } (S^i, \sigma(S^{-i})) = (VC, j)) \end{cases}$$

where $q \in (0, 1)$ is the tax rate.[18]

The mechanism is budget balanced because it equally redistributes to all the j responsible buyers the total amount levied from the $n - j$ conventional buyers. More formally, if j citizens vote responsibly, we require that the transfers θ^i_{pc} are in Θ, that is

$$\sum_{i=1}^{N} \theta^i = (n - j)qc - (n - j)qc = 0.$$

Once the mechanism is applied, the payoffs are

$$\begin{aligned} F^i_{pc}(S^i, \sigma(S^{-i})) &= \begin{cases} \frac{j+1}{n} b + a - c + \theta^i_{pc} & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ \frac{j}{n} b + \theta^i_{pc} & \text{if } (S^i, \sigma(S^{-i})) = (VC, j) \end{cases} \\ &= \begin{cases} \frac{j+1}{n} b + a + (\frac{n-j-1}{j+1} q - 1)c & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ \frac{j}{n} b - qc & \text{if } (S^i, \sigma(S^{-i})) = (VC, j) \end{cases} \end{aligned} \tag{5}$$

The following proposition characterises the condition of mutual responsible voting as a NE, under the proportional cost mechanism.

Proposition 3. *Let G_n be the vote with the wallet game described in* (1) *and $\Gamma_{pc} = (G_n, \Theta, F^i_{pc})$ the controlled game described in (2), where F^i_{pc} is the mechanism as in (5). Then mutual responsible voting is a NE of Γ_{pc} if and only if*

$$c \leq \frac{\frac{1}{n} b + a}{1 - q}$$

or, alternatively,

$$q \geq 1 - \frac{\frac{1}{n} b + a}{c}$$

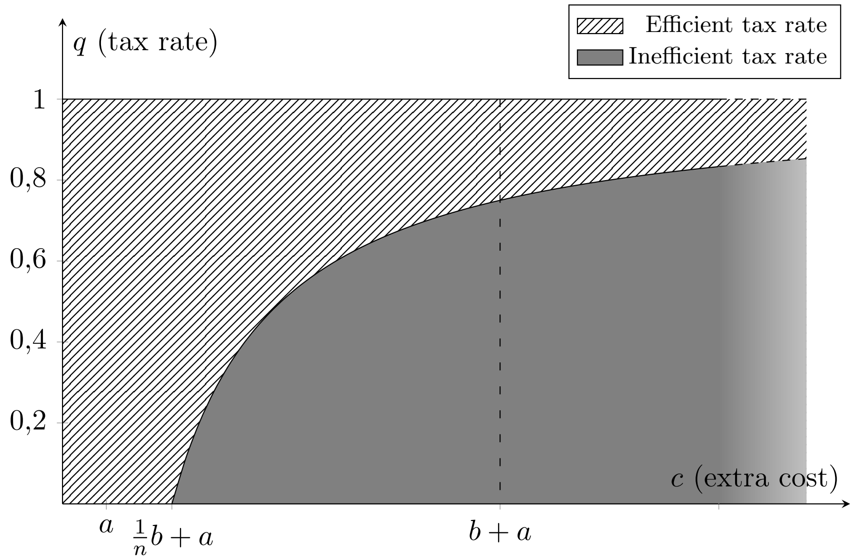
where $q \in (0, 1)$ is the tax rate levied by the government on the conventional buyers.

Proof. See Appendix A. □

Given the parameters of the game, Proposition 3 allows us to calculate the maximum extra-cost enforcing mutual responsible voting as a NE with the proportional cost mechanism. As we can see, the higher is the tax rate q, the higher the extra-cost can be, since q is the incentive that the government gives to players to vote for responsible

[18] As above, we do not consider the case $q = 0$ since it corresponds to the absence of redistribution. We also skip the trivial case $q = 1$, since it makes mutual responsible voting always a NE.

Figure 3: Effective tax rates and the cost of buying responsibly (Proportional cost mechanism).



products. From another perspective, Proposition 3 suggests the minimum tax rate the government can set in order to obtain mutual responsible voting as a NE. As we expected, it is decreasing in a and b, and increasing in c.

For each value of extra-cost c, the proportional cost mechanism always allows for one efficient tax rate q (Figure 3). As the proportional free-rider gain mechanism in section III.1, for low values of c (i.e., $c \leq \frac{1}{n}b + a$), each tax rate q enforces mutual responsible voting as a NE, while for higher values of c (i.e., $\frac{1}{n}b + a < c \leq b + a$), there exists a minimum tax rate q (i.e., $q = 1 - \frac{1}{c}(\frac{1}{n}b + a)$) that enforces mutual voting as a NE (white grey striped area). Interestingly, as c increases (i.e., $c > b + a$), the minimum tax rate q also increases, but it is always lower than 1. Therefore, with the proportional cost mechanism the government can always enforce the mutual responsible voting as a NE by setting a tax rate $q \in (0, 1)$ – even when the extra cost c is greater than $b + a$.

III.3 The lump-sum tax mechanism

According to the lump-sum mechanism the government levies a lump-sum tax $k \in (0, +\infty)$ on each conventional buyer and equally redistributes the total amount to each responsible buyer.[19]

For each player $i = 1, \ldots, N$ adopting the strategy S_t^i at time t the lump-sum mechanism is described by

$$\theta_{ls}^i := \theta_{ls}^i(S_t^i, \sigma(S_t^{-i})) = \begin{cases} k\frac{n-j-1}{j+1} & \text{if } (S_t^i, \sigma(S_t^{-i})) = (VR, j) \\ -k & \text{if } (S_t^i, \sigma(S_t^{-i})) = (VC, j) \end{cases}$$

[19] We do not restrict the lump-sum tax with a maximum bound. However, it is reasonable to assume that $k \leq \frac{n-1}{n}b$, in order to avoid the case of negative payoff in case of one free-rider only.

This mechanism punishes conventional buyers irrespective of how many they are, while the premium for responsible buyers grows as they are scarce (and the conventional buyers are abundant).

The mechanism is budget balanced, since the government equally redistributes to j responsible buyers the amount $k(n-j)$, which is the total amount of lump-sum taxes levied to the $(n-j)$ conventional buyers. The redistribution award for responsible buyers is inversely related to the share of responsible buyers over total players and can become a winner-takes-it-all mechanism if there is only one buyer in the players' pool. The balanced budget equation writes

$$BC = jk\frac{n-j}{j} - k(n-j) = 0$$

In the extreme case of $j = 0$, which occurs when there are no responsible buyers, the government can keep the tax and end with a (strictly) positive budget.

The payoff function after the mechanism writes

$$\begin{aligned} F^i_{ls}(S^i, \sigma(S^{-i})) &= \begin{cases} \frac{j+1}{n}b + a - c + \theta^i_{ls} & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ \frac{j}{n}b + \theta^i_{ls} & \text{if } (S^i, \sigma(S^{-i})) = (VC, j) \end{cases} \\ &= \begin{cases} \frac{j+1}{n}b + a - c + \frac{k(n-j-1)}{j+1} & \text{if } (S^i, \sigma(S^{-i})) = (VR, j) \\ \frac{j}{n}b - k & \text{if } (S^i, \sigma(S^{-i})) = (VC, j) \end{cases} \end{aligned} \tag{6}$$

Proposition 4. *Let G_n be the voting with the wallet game described in* (1) *and $\Gamma_{ls} = (G_n, \Theta, F^i_{ls})$ the controlled game described in* (2)*, where F^i_{ls} is the mechanism as in* (6)*. Then mutual responsible voting is a NE of Γ_{ls} if and only if*

$$c \leq \frac{1}{n}b + a + k$$

or, alternatively,

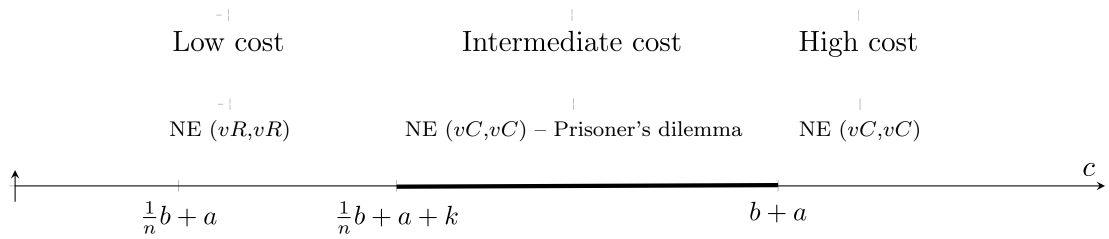
$$k \geq \frac{1}{n}b + a - c$$

where $k \in (0, +\infty)$ is the lump-sum tax levied by the government on the conventional buyers.

Proof. See Appendix A. □

As we can see from Figure 4, the lump-sum mechanism always reduces the PD interval by the same amount of the tax, k. Therefore, a high tax k (i.e., $k = \frac{n-1}{n}b$) makes the NE of the game – which are now mutual responsible voting for $c \leq b + a$ and mutual conventional voting otherwise – always efficient. Moreover, when knowing the value of the parameters a, b, and c, it is always possible to set a lump-sum tax k such that mutual responsible voting is the unique (efficient) NE.

Figure 4: Changes in the intervals of equilibria along the segment of c values in the multiplayer game with the lump-sum mechanism.



III.4 The subsidy mechanism

The fourth policy mechanism consists in a fixed sum subsidy applied by the government to provide incentives for voting responsibly. The subsidy is financed by the conventional buyers.

For each player $i = 1, \ldots, N$ adopting the strategy S_t^i at time t the subsidy mechanism is described by

$$\theta_s^i := \theta_s^i(S_t^i, \sigma(S_t^{-i})) = \begin{cases} k & \text{if } (S_t^i, \sigma(S_t^{-i})) = (VR, j) \\ -\frac{kj}{n-j} & \text{if } (S_t^i, \sigma(S_t^{-i})) = (VC, j)) \end{cases}$$

The subsidy mechanism rewards the responsible buyers equally, as far as there is at least one conventional buyer. However, in the extreme case of $j = n$ we have that the government cannot levy tax on the conventional buyers and therefore is not able to provide incentives to vote responsibly. Thus, in order to have that each responsible buyer is always rewarded by the government subsidy, both when any individual votes conventionally and all individuals vote responsibly, we assume for this mechanism that the government has an endowment of K to be equally redistributed to the responsible buyers.[20] mechanism that rewards responsible buyers as there are some conventional buyers, and does not rewards responsible buyers if all citizens are responsible buyers. This changes the idea of the mechanism to reward responsible buyers, and therefore we do not address this case. Therefore, the subsidy mechanism is now described by

$$\theta_s'^i := \theta_s'^i(S_t^i, \sigma(S_t^{-i})) = \begin{cases} \frac{K}{n} & \text{if } (S_t^i, \sigma(S_t^{-i})) = (vR, j) \\ -\frac{\frac{K}{n}j}{n-j} & \text{if } (S_t^i, \sigma(S_t^{-i})) = (vC, j)) \end{cases}.$$

This new mechanism equally awards each responsible buyer by $\frac{K}{n}$. The difference now is that, in presence of at (least one) conventional buyer(s), the total amount of awards for the responsible buyers (i.e., $\frac{K}{n}j$) is covered by the conventional buyer(s), while, if all citizens vote responsibly, then the government is able to award the responsible buyers through its endowment K.

[20] If we do not assume an initial endowment, then the government should implement a budget balanced

The payoff function after the mechanism writes

$$F_s^i(S^i,\sigma(S^{-i})) = \begin{cases} \frac{j+1}{n}b + a - c + \theta_s'^i & \text{if } (S^i,\sigma(S^{-i})) = (VR,j) \\ \frac{j}{n}b + \theta_s'^i & \text{if } (S^i,\sigma(S^{-i})) = (VC,j) \end{cases} = \begin{cases} \frac{j+1}{n}b + a - c + \frac{K}{n} & \text{if } (S^i,\sigma(S^{-i})) = (VR,j) \\ \frac{j}{n}b - \frac{\frac{K}{n}j}{n-j} & \text{if } (S^i,\sigma(S^{-i})) = (VC,j) \end{cases} \tag{7}$$

The mechanism is budget balanced, since the government equally levies on $n-j$ conventional buyers the amount $\frac{K}{n}j$, which is the total amount of the subsidies for the j responsible buyers, and in case of no conventional buyers the government endowment K is used for subsidies. The balanced budget equation writes

$$BC = \frac{K}{n}j - (n-j)\frac{K}{n}\frac{j}{n-j} = 0$$

and in case of $j = n$ the government is still able to provide subsidies through its initial endowment K.

Proposition 5. *Let G_n be the vote with the wallet game described in* (1) *and $\Gamma_s = (G_n, \Theta, F_s^i)$ the controlled game described in* (2)*, where F_s^i is the subsidy mechanism as in* (7)*. Then mutual responsible voting is a NE of Γ_s if and only if*

$$c \leq \frac{1}{n}b + a + K,$$

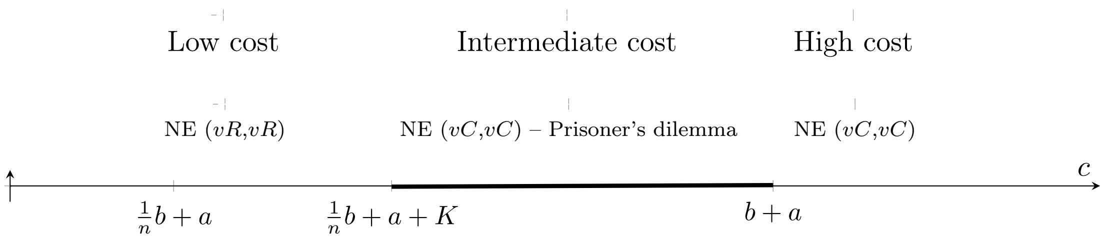
where $K \in (0, +\infty)$ is the government initial endowment.

Proof. See Appendix A. □

Proposition 5 states the maximum value of the extra cost c that enforces mutual voting as a NE. Thus, the subsidy mechanism reduces the PD interval by K, which is the government initial endowment (Figure 5). This result looks like the lump-sum tax mechanism. However, the role of lump-sum tax in the lump-sum mechanism is now played by the subsidy, and this difference is slight but important. If the government taxes conventional voters, and redistributes the total tax return to responsible voters, it can enforce mutual responsible voting as a NE, therefore avoiding any presence of conventional voters and consequentially not rewarding any responsible voters. In the subsidy mechanism, since the government aims to reward responsible voters, in case of mutual responsible voting equilibrium (and then absence of conventional voters) the government must provide subsidies to responsible voters, and therefore draw from its initial endowment.

In Table 1 we resume the results of the four mechanisms in terms of the minimum extra-cost of the responsible product which allows to achieve the mutual responsible voting as a NE. We can see that the government is able to reduce the PD interval with all the mechanisms. In other words, for certain values a, b, and c we have that, before

Figure 5: Changes in the intervals of equilibria along the segment of c values in the multiplayer game with the subsidy mechanism.



the mechanism is implemented, mutual conventional voting is the NE, but it is not efficient, and, after the mechanism is applied, mutual responsible voting is the NE, which is now efficient. In particular, with the first two mechanisms (i.e., Proportional and the Proportional cost) the government is able to reduce the PD interval proportionally to, respectively, the share of benefit and the share of cost that the government decides to redistribute. On the other hand, the last two mechanisms (i.e., Lump-sum tax and Subsidy) make the government able to reduce the PD interval by a fixed amount, which is given, respectively, by the tax and the subsidy set by the government.

We advice policy-makers to focus particularly on the proportional cost and the lump-sum tax mechanism. The proportional cost mechanism has the advantage that it is easily implementable, since it works on the extra-cost, which is quantifiable, and as a consequence it could ultimately coerce conventional product producers to adjust the prices. Moreover, it always allows for a tax rate that makes mutual voting an efficient NE. The lump-sum tax mechanism is also easily implementable, since it sets a fixed tax. Moreover, in case of no responsible voters, the government ends with a positive budget, which can used to alleviate the inefficiency of mutual conventional voting in terms of social and environmental impact.

On the other hand, the other two mechanisms (Proportional free-ride gain and Subsidy) are not recommended. Drawbacks of the former hinge on the fact that a public benefit (i.e., the parameter b) is not always a taxable good or service, and drawbacks of the latter are related to the government initial endowment, as previously discussed.

IV Discussion

In this section we discuss some implications of our model. We start with an analysis of the already existing redistribution schemes that are closest to those described in our theoretical framework. Then, we discuss similarities and differences with our benchmark model and with the four redistribution mechanisms. Finally, we reason on the heuristic power of our theoretical approach and discuss possible insights, which aim to provide the implementation of the existing schemes and the construction of similar schemes in related fields.

The most successful example of redistribution scheme providing premia to re-

Table 1: Extra-cost allowing for mutual responsible voting (by mechanism)

Mechanism	**Minimum extra-cost**
Proportional	$c = \frac{nq+1-q}{n}b + a$
Proportional cost	$c = \frac{1}{1-q}(\frac{1}{n}b + a)$
Lump-sum	$c = \frac{1}{n}b + a + k$
Subsidy	$c = \frac{1}{n}b + a + K$

sponsible buyers and penalties to standard buyers is the *feed-in tariff* (FIT). The FIT scheme aims at the promotion of energy production from photovoltaic system. The mechanism provides subsidies to renewable energy consumers and charges the cost on the rest of taxpayers.[21] These schemes are currently implemented in 63 countries worldwide and are regarded as one of the most effective measures to promote the development of renewable energy sources (Couture and Gagnon, 2010; Klein et al., 2008; Mendonça, 2007; European Commission, 2008; REN21, 2009). More in detail, the system consists in the offer of a non-discriminatory guaranteed subsidised price for a given period of time (long-term contracts) renewable generators, such as homeowners, business owners, and farmers. The price may vary according to the characteristics of the installation.

FIT schemes may be related to our subsidy mechanism described in section III.4. The public good b is environmental sustainability, and its level of provision depends on the share of renewable energy consumers. The extra cost c is the cost differential between installing and operating photovoltaic energy vis-á-vis the alternative energy from non renewable sources. The parameter a is captured by the unobservable heterogeneous satisfaction that an environmentally conscious citizen enjoys when opting for renewable energy. The parameter a plays a crucial role in explaining why some citizens do opt for renewable energy and some others do not, in the presence of a non discriminatory subsidy per kWh of electricity produced. Many FIT schemes (such as the one implemented in Italy) are akin to our subsidy mechanism in the model, since the aggregate subsidy for cooperators (i.e., consumers installing photovoltaic systems) is charged on the bill of all consumers, and therefore on the shoulders of defectors.[22] All other FIT schemes follow implicitly the same approach if the program is implemented within a fixed government budget goal.[23]

[21] For the European regulation on FIT see Directive 2001/77/EC of the European Parliament and of the Council.

[22] More precisely, each renewable energy consumer receives a net subsidy equal to the gross subsidy provided by the FIT scheme minus the tax charged on the bill (as every taxpayers is charged), while a conventional energy consumers is charged by the tax on the bill only.

[23] Note as well that in FIT schemes "cooperators" (i.e., responsible buyers) are fully aware of the pre-

In what follows we wonder whether the same redistribution approach used for FIT schemes can be successfully applied to other situations with two examples.

A first example is green consumption taxes, that is, taxes which are lower (higher) for more (less) environmentally sustainable products. This is the case of a green VAT reform in EU, which is strongly supported by Albrecht (2006).[24] It is important to remark that green consumption tax is different from Pigouvian tax since the former works on the demand while the latter on the supply side. A limit of Pigouvian tax in globally integrated markets is that, when implemented in a single country, it may produce delocalisation and crowding out of domestic production if profit maximising corporations try to reduce production costs. This concern is by far reduced if the tax reform is implemented at EU level and competitors from countries in which the green consumption tax is not implemented have significant market shares in the EU. As well it must be remembered that the mechanisms proposed in our model have a premium and a penalty side, and therefore provides incentives for producers improving their environmental sustainability, which may make them stronger vis-á-vis foreign competitors. The environmental sustainability improvements can also drives sustainable innovation patterns, which are expected to be more and more important in the future, given particular concerns such as the climate change issue. One of the main problem of our analysis is obviously a clear-cut and accepted distinction between the ethical and the standard product, which may be however solved relying on publicly available information on social and environmental rating agencies.

Our second example concerns the Italian Competition Authority – an independent agency tasked with enforcing the Competition Act (Law No. 287 of 10 October 1990). Competition Authority created the so called *legality ratings*, that are ratings based on social and legality aspects of the companies, and assign a 1-3 stars evaluation to companies that accept to be evaluated. The rating is higher when the company has a clean score in terms of tax and legal compliance and demonstrates commitment to CSR. Legality rating could be the base for the application of redistribution mechanisms described in this paper. The legality rating example is different from the FIT scheme, since it is a public institution (i.e., a regulatory authority) which creates the information infrastructure (i.e., the legality rating) required to apply the scheme.

The above mentioned examples document that redistribution schemes similar to those described in our analysis may become widespread in the future, thereby making

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mium while "defectors" (i.e., conventional buyers) may not necessarily be aware of the penalty implied in the scheme. The issue is however beyond theoretical analysis of this paper where we assume perfect information of all agents. It is easy to understand that lack of full awareness of penalties for conventional buyers may significantly reduce the capacity of the redistribution mechanism of enforcing mutual responsible voting as a NE. Hence, if the goal is to maximise the share of responsible voters, the logical policy advice is that of making conventional voters fully aware of the penalty arising from their choices.

[24] Accordingly, Marconi (2010) illustrates that in a two-country general equilibrium model with endogenous growth and trade, an unilateral green consumption tax changes demand patterns and increase technological progress in the direction of pollution abatement in both countries. Sall and Green (2012) calculate that the introduction of a green consumption tax on meat (28 percent, 26 percent, and 40 percent of the price per kg of beef, pork, and poultry respectively in 2009) could decrease emission of greenhouse gas, nitrogen, phosphorus, and ammonia by at least 27 percent.

the theoretical analysis developed in this paper of foremost importance. In our model we proposed four mechanisms – proportional free-rider gain, proportional cost, lump-sum tax, and subsidy – and wonder how each of them may contribute to enforce cooperative strategies as a NE.

A first relevant result is that all mechanisms (with the exception of the fourth in a specific case) contribute to extend the parametric interval of mutual cooperative equilibrium without extra costs for the government budget. A second important result is that, among the three mechanisms that do not require extra expenditure from the government, the proportional cost mechanism has two advantages. First, it is based on a clearly observable parameter (the extra-cost between the responsible and the standard product). Second, with this approach it is possible to find for any level of c the optimal tax rate q (i.e., the share of the extra cost that each conventional consumer has to pay to responsible consumers), which ensures mutual responsible voting as a NE. This second advantage is not obtained in any of the other three mechanisms.

A further important result of our paper is that the scheme that is among the most adopted in practice (i.e., FIT, that corresponds to the subsidy mechanism) tends to be unsustainable in case of success. Based on our model, if all the citizens vote responsibly (e.g., adopt a renewable energy contract), the total amount of subsidies (e.g., the FITs) must be paid by the government, since there are not anymore conventional voters. For the case of FIT, which are offered through long-term contracts, this is particularly relevant if we assume that it is highly likely that in the next decades renewable energy will be adopted by the majority (or the totality) of citizens. Note however that in our model we assume homogeneity of players' preferences. As a consequence, all players will make the same choice in the game. An interesting extension of the game would be to see what happens when this assumption is removed and heterogeneity in the other regarding preference parameter is assumed. In the view of what observed with our theoretical framework, the second scheme seems the best mechanism. However, in the extreme case of zero conventional buyers, the government must honour its commitment with extra public expenditure.

V Conclusion

Is it possible to stimulate the production of (some specific forms of) public goods without any government extra expenditure? In this paper we demonstrate that this is achievable (and desirable) if the government builds ad hoc redistribution mechanisms exploiting the willingness to vote with the wallet for responsible companies' products of a share of the population, which we term as *responsible voters*.

In our paper we start from the consideration that, more and more, millions of consumers and investors in the world face in their everyday life the alternative between choosing a conventional and a responsible product. We argue that this choice has the characteristics of a multiplayer prisoners' dilemma and wonder how simple policy mechanisms redistributing away from conventional to responsible buyers may bridge the gap between the non cooperative NE and social optimum. In our theoretical model we analyse the characteristics of four redistribution mechanisms, provide insights for existing policy solutions such as FITs, and discuss their potential application to new similar schemes.

Our theoretical findings document that all of the four redistribution mechanisms have the property of extending significantly the parametric interval in which mutual responsible voting can be enforced as a NE. When discriminating among them, we however find that the scheme which seems closer to what actually adopted in real life policies (such as FITs), i.e. the subsidy mechanism, is paradoxically the only one not compatible with zero extra government extra costs (if we assume that long-term contracts does not allow not to reward responsible voters in case of absence of conventional voters). We further document that the first two mechanisms (i.e., the proportional free-rider gain and the proportional cost) imply respectively the redistribution of part of the conventional consumers' differential payoff and of the extra-cost paid by responsible consumers. In both cases we calculate the optimal tax share enforcing the cooperative equilibrium conditional to the model parameters. The proportional cost mechanism has the advantage of producing an optimal share for any point of the parametric interval of the extra cost c, a property that the does not hold for the other three mechanisms.

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A Appendix

Proof of Proposition 1. We want to show that mutual responsible voting is a NE of the game Γ_p if and only if $\frac{n+1}{2n}b+a \geq c$. Without loss of generality, we set $\bar{j} = \sigma(S^{-i})$ and we have that $(VR, \bar{j})$ is a NE of Γ_p if and only if for each $i \in N$, $F_p^i(VR, \bar{j}) \geq F_p^i(VC, \bar{j})$, that is $\frac{n+1}{2n}b + a \geq c$. Now, since this holds for any $i \in N$ and for any $\bar{j} = 0, \ldots, n-1$, then each responsible buyer has no profitable deviation while each conventional buyer has always a profitable deviation. Therefore, mutual responsible voting is a NE of Γ_p if and only if $\frac{n+1}{2n}b + a \geq c$, and if $\frac{1}{n}(nq+1-q)b+a > c$ the equilibrium is unique. □

Proof of Proposition 2. We want to show that mutual responsible voting is a NE of the game Γ_{p_q} if and only if $\frac{1}{n}(nq+1-q)b+a \geq c$. As we have done in the proof of Proposition 1, without loss of generality we set $\bar{j} = \sigma(S^{-i})$ and we have that $(VR, \bar{j})$ is a NE of Γ_{p_q} if and only if for each $i \in N$, $F_{p_q}^i(VR, \bar{j}) \geq F_{p_q}^i(VC, \bar{j})$, that is $\frac{1}{n}(nq+1-q)b + a \geq c$. Now, since this holds for any $i \in N$ and for any $\bar{j} = 0, \ldots, n-1$, then each responsible buyer has no profitable deviation while each conventional buyer has always a profitable deviation. Therefore, mutual responsible voting is a NE of Γ_p if and only if $\frac{1}{n}(nq+1-q)b + a \geq c$. Moreover, if $\frac{1}{n}(nq+1-q)b + a > c$, the equilibrium is unique. □

Proof of Proposition 3. We want to show that mutual responsible voting is a NE of the game Γ_{pc} if and only if $\frac{1}{1-q}(\frac{1}{n}b + a) \geq c$. As shown in the previously proofs, without loss of generality we set $\bar{j} = \sigma(S^{-i})$ and we have that $(VR, \bar{j})$ is a NE of Γ_{pc} if and only if for each $i \in N$, $F_{pc}^i(VR, \bar{j}) \geq F_{pc}^i(VC, \bar{j})$, that is $\frac{1}{1-\frac{n}{\bar{j}+1}q}(\frac{1}{n}b + a) \geq c$. Now, since this holds for any $i \in N$ and for any $\bar{j} = 0, \ldots, n-1$, then each responsible buyer has no profitable deviation while each conventional buyer has always a profitable deviation. Therefore the number of responsible buyers (i.e., $\bar{j}+1$), must be equal to the number of citizens (i.e., n), that is mutual responsible voting is a Nash equilibrium of Γ_{ls} if and only if $\frac{1}{1-q}(\frac{1}{n}b + a) \geq c$. Moreover, if $\frac{1}{1-q}(\frac{1}{n}b + a) > c$, the equilibrium is unique. □

Proof of Proposition 4. We want to show that mutual responsible voting is a NE of the game Γ_{ls} if and only if $\frac{1}{n}b + a + k \geq c$, where k is the lump-sum tax levied on each conventional buyer. Formally, we set $\bar{j} = \sigma(S^{-i})$ and we have that $(VR, \bar{j})$ is a NE of Γ_{ls} if and only if for each $i \in N$, $(VR, \bar{j})$ is a NE of Γ_{ls} if and only if for each $i \in N$, $F_{ls}^i(VR, \bar{j}) \geq F_{ls}^i(VC, \bar{j})$, that is $\frac{1}{n}b + a + \frac{n}{\bar{j}+1}k \geq c$. Since this holds for any $i \in N$ and for any $\bar{j} = 0, \ldots, n-1$, then each responsible buyer has no profitable deviation while each conventional buyer has always a profitable deviation. Therefore the number of responsible buyers (i.e., $\bar{j}+1$), must be equal to the number of citizens (i.e., n), that is mutual responsible voting is a Nash equilibrium of Γ_{ls} if and only if $\frac{1}{n}b + a + k \geq c$. Moreover, if $\frac{1}{n}b + a + k > c$, the equilibrium is unique. □

Proof of Proposition 5. We want to show that mutual responsible voting is a NE of the game Γ_s if and only if $\frac{1}{n}b + a + \frac{K}{n}(2-n) \geq c$, where $K > 0$ is the initial endowment of the government. Formally, we set $\bar{j} = \sigma(S^{-i})$ and we have that $(VR, \bar{j})$ is a NE of Γ_s if and only if for each $i \in N$, $F_s^i(VR, \bar{j}) \geq F_s^i(VC, \bar{j})$, that is $\frac{1}{n}b + a + \frac{K}{n}(\frac{n}{n-\bar{j}}) \geq c$. Since this holds for any $i \in N$ and for any $\bar{j} = 0, \ldots, n-1$, then each responsible buyer has no profitable deviation while each conventional buyer has always a profitable deviation. Therefore the number of responsible buyers (i.e., $\bar{j}+1$), must be equal to the number of citizens (i.e., n), that is, mutual responsible voting is a Nash equilibrium of Γ_s if and only if $\frac{1}{n}b + a + K \geq c$. Moreover, if $\frac{1}{n}b + a + K > c$, the equilibrium is unique. □