Environmental Corporate Social Responsibility as a Collusive Device*

Kosuke Hirose†, Sang-Ho Lee‡, and Toshihiro Matsumura§

May 1, 2017

Abstract

We formulate a model in which an industry association chooses whether environmental corporate social responsibility (ECSR) is adopted and then firms compete in the market. First, we consider emission cap commitment as ECSR. Under quantity competition, ECSR is adopted by the joint-profit-maximizing industry association because it serves as a collusive device, although ECSR is not adopted if firms choose it independently. By contrast, under price competition, individual firms voluntarily adopt ECSR but the industry association chooses a higher level of ECSR. These findings together suggest that industry associations have a stronger incentive to encourage firms to adopt ECSR than each firm working alone. Furthermore, ECSR can harm social welfare because it restricts competition. Next, we consider emission standard commitment (commitment to per-output emissions) which we find is less likely than emission cap commitment to restrict competition and is not harmful for consumers.

JEL classification codes: M14, Q57, L13

Keywords: corporate social responsibility, collusion, emission cap, emission standard

*We thank the seminar participants at Osaka University, The University of Tokyo, Hiroshima University, Aoyama Gakuin University, University of Salento, University of Ferrara, University of the Thai Chamber of Commerce, and National University of Kaohsiung for their helpful comments. We are responsible for any remaining errors. This work was supported by the National Research Foundation of Korea Grant (NRF-2014S1A2A2028188) and JSPS KAKENHI (15K03347,16J04589).

† Corresponding author: Graduate School of Economics, The University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, Tokyo, 113-0033, Japan. E-mail: h-kosuke@g.ecc.u-tokyo.ac.jp

‡College of Business Administration, Chonnam National University, E-mail:sangho@chonnam.ac.kr

§Institute of Social Science, The University of Tokyo, E-mail:matsumur@iss.u-tokyo.ac.jp

1 Introduction

There are broad arguments about how instrumental differences among environmental policies affect firms' incentives and whether they improve or worsen environmental problems. Traditionally, governments have formed command-and-control regulations, taxes, and subsidies. Recently, however, a new approach, voluntary participation by firms or industry associations, has been introduced in environmental policies.[1] This voluntary approach beyond compliance has some advantages over the traditional mandatory regulations.[2] For example, it could be quickly and flexibly implemented because no conflict exists between policymakers and firms. Although this self-regulation has been widely adopted in recent decades, the effects and mechanism are not well understood either theoretically or empirically. Voluntary emission reduction (i.e. abatement) will increase a company's own cost and thus, might cause a cost disadvantage when the company's rivals do not participate in the voluntary emission reduction cooperatively. In addition, if all firms accept higher costs to engage in the voluntary agreement, who pays for these higher costs? Thus, it is important to investigate why the voluntary approach works in markets and how it affects the economy.

As voluntary participation in environmental issues, environmental corporate social responsibility (ECSR) has received increasing attention from both natural and social science researchers. Economic researchers have intensively discussed this problem recently (Maxwell et al., 2000; Lyon and Maxwell, 2004; Lambertini and Tampieriz, 2015; Liu et al., 2015) because many listed firms are highly concerned about ECSR (KPMG, 2013). The CDP (2013), for example, reported that major companies, such as ExxonMobil, Walt Disney, Walmart, and Microsoft, use an internal (implicit) carbon price as an incentive and a strategic plan-

[1]Because of worldwide political pressures concerning climate change, many polluting companies are voluntarily reducing their energy use or greenhouse gas (GHG) emissions and actively participating in GHG emissions reporting programs. For example, in 2014, 26 major firms in the power generation, cement production, and steel sectors in Korea voluntarily declared they would reduce fine dust. Most recently, EuroVAprint, which is composed of leading European printer and copier manufacturers, has established a voluntary agreement, and its activities are ongoing.

[2]See Vogel (2005), McWilliams et al. (2006), and Calveras et al. (2007).

ning tool. Although ECSR is costly, recent analysis suggests that it can form part of an optimal firm strategy if society rewards social behavior.[3] Some empirical works have suggested that the financial performance of those firms believed to be highly concerned with ECSR is better.[4] There are two well-known reasons why voluntary approaches work in the market. One possible explanation in the field is that ECSR is connected with advertisement or public reputation of firms and thus, it eventually could change consumer preferences and ultimately individual behaviour. If consumers bear at least some of the negative externalities and value ECSR, these firms adopting ECSR could obtain increased demand, and thereby earn more profits (see Liu et al., 2015, and works cited therein). The other is that voluntary agreement can be used as a countermeasure for the regulatory threat by the government, which allows firms to avoid the public regulation (see Maxwell et al., 2000 and Antweiler, 2003).

In this study, however, we extend the body of knowledge on strategic ECSR by demonstrating that adopting ECSR can be profitable for firms even if it neither raises their reputations nor be the countermeasure for the regulation threat. In particular, we shed light on the role of industry associations, which play important roles in the adoption of ECSR.[5]

We discuss two kinds of ECSR. One is emission cap commitment (firms commit to an

[3]As McWilliams and Siegel (2001) and Baron (2008) argued, this strategic behavior can be interpreted as a market-driven interaction to maximize the profits induced by the demand side or as a hedge against the risk of future regulation or activism. See also Kitzmueller and Shimshack (2012). Recent works, such as Goering (2014) and Brand and Grothe (2015), have considered a bilateral monopoly and showed that firms voluntarily adopt corporate social responsibility (CSR) to increase their profits. In their model, CSR implies that firms are concerned about consumer surplus.

[4]Margolis et al. (2007) used meta-analysis and detected a modest positive average correlation between CSR and corporate financial performance).

[5]Many industry and economic associations play leading roles in ECSR, such as the Japan Association of Corporate Executives, Japan Business Federation, Japan Iron and Steel Federation, Federation of Electric Power Companies of Japan, and the Federation of German Industries (Bundesverband der Deutschen Industrie), which is an alliance of associations, including many influential industrial sector associations in Germany. In addition, the business community has formed its own organizations specializing in CSR. For example, Business for Social Responsibility (BSR) is a business association founded in 1992 to provide corporations with expertise on the subject and to provide an opportunity for business executives to advance the field and learn from one another. See Carroll and Shabana (2010) for further discussion on BSR practices of business associations.

upper bound of emissions). Committing to reduce total emissions is equivalent to a cap of emission levels. The concept builds on absolute emission targets. Examples include many companies in the energy and semiconductor industries in the US and UK (see Margolick and Russell, 2001; Lee, 2010), among which NRG Energy, a leading energy company in the US, is a typical example (Cardwell, 2014). Furthermore, according to the CSR reports of the Japan Association of Corporate Executives and Japan Business Federation, many major Japanese firms have adopted such commitments. The other kind of ECSR is emission standard commitment (firms commit to emission level per unit of output). Firms belonging to the Federation of Electric Power Companies of Japan, an association of dominant electric companies in 10 areas in Japan, committed to an emission standard before the Great East Japan Earthquake in 2011.[6]

In each of the above two types of ECSR, we formulate the following three-stage duopoly game. In the first stage, each firm or the industry association to which both firms belong chooses the level of commitment as ECSR. In the second stage, the firms compete in the market. In the third stage, they engage in emission abatement activities.

Emission cap commitment yields the following results. In a quantity competition model, the industry association chooses a strictly positive degree of ECSR, although ECSR is not adopted if individual firms choose not to. By contrast, in a price competition model, even individual firms voluntarily adopt a positive degree of ECSR. Nevertheless, the industry association chooses a higher level of ECSR. These findings together suggest that industry associations have a stronger incentive to encourage firms to adopt ECSR than each firm working alone. In addition, we show that ECSR may harm welfare, either in Bertrand competition or Cournot competition, because ECSR restricts competition and raises prices.

Anti-trust legislation prevents collusion in prices or quantities, and thus, prohibits the formation of price or quantity cartels. However, it is unclear whether firms cooperate when

[6]For examples and discussions on emission standards, see Helfand (1991), Farzin (2003), and Lahiri and Ono (2007).

choosing their degrees of ECSR in the face of such regulations. Indeed, business and industry associations often play a leading role in the adoption of ECSR by members. For example, many Japanese associations, such as the Japan Association of Corporate Executives, Japan Business Federation, Japan Iron and Steel Federation, and Federation of Electric Power Companies of Japan, emphasize ECSR in their reports and on their websites, and encourage – and often force – member firms to adopt ECSR. Thus, we believe that cooperation in forming ECSR is quite natural and realistic.

The emission standard commitment has contrasting implications. Even a joint-profit-maximizing industry association might not choose a positive degree of ECSR when it chooses the emission standard. When it chooses this standard, the cap of total emissions is proportional to the output level. Thus, the output-restriction effect of ECSR under the emission standard is weaker than that under the emission cap. This yields contrasting results for the emission standard and emission cap.

This result suggests that ECSR by emission standard is less likely to restrict competition. If the emission standard is adopted by the association, the ECSR is more likely to be formed for the purpose of benevolence or improving industry image, such as advertising, rather than for the purpose enhancing collusion.

This type of ECSR was adopted by the Federation of Electric Power Companies of Japan before the Great East Japan Earthquake. The members of this association were dominant electric companies of from 10 areas in Japan, each with 90–100% market share in its area. Because competition was very weak in the Japanese electric power market, the association had little incentive to induce collusion by ECSR. Therefore, we guess that they adopted this type of ECSR for the purpose of improving industry image.

The rest of this paper is organized as follows. Section 2 presents the basic model of emission cap commitments. Sections 3 and 4 investigate quantity and price competition, respectively, and present our main results. Section 5 shows that emission standard commitments yield contrasting results to emission cap and implicit emission price commitments. Section 6 concludes.

2 The Model

We consider a symmetric duopoly model. There are two identical firms, firms 1 and 2, producing homogeneous commodities[7] for which the inverse demand function is given by $P(Q) : \mathbb{R}_+ \mapsto \mathbb{R}_+$. We assume that $P(Q)$ is twice continuously differentiable and $P'(Q) < 0$ for all Q as long as $P > 0$. Let $C(q_i) : \mathbb{R}_+ \mapsto \mathbb{R}_+$ be the cost function of firm i, where $q_i \in \mathbb{R}_+$ is the output of firm i. We suppose C is twice continuously differentiable, increasing, and convex for all q_i.[8] We assume that the marginal revenue is decreasing (i.e. $P'(Q)+P''(Q)q_i < 0$). Under quantity competition, this guarantees that the strategies are strategic substitutes and that the second-order condition and the stability condition are satisfied.

There are emissions associated with the production, which yields a negative externality. Firm i's emission level is $g(q_i) - x_i$, where $g : \mathbb{R}_+ \mapsto \mathbb{R}_+$ is emissions associated with production and $x_i (\in \mathbb{R}_+)$ is firm i's abatement level. We assume that g is twice continuously differentiable, increasing, and convex for all q_i.

Firm i $(i = 1, 2)$ adopts emission cap T_i and commits to $g(q_i) - x_i \leq T_i$. Firm i chooses a strictly positive x_i if and only if the emission cap constraint is binding. We regard that firms adopt ECSR if and only if the emission cap constraint is binding, and thus, $x > 0$ in equilibrium.

Firm i's profit is

$$P(Q)q_i - C(q_i) - K(x_i),$$

where the third term represents the abatement cost. We suppose that K is twice contin-

[7] We can show that Propositions 1 and 2 hold even if we introduce product differentiation that is discussed in Section 4 under moderate conditions. Proposition 1 holds if the strategies are strategic substitutes and the stability condition is satisfied in the quantity-competition stage and Proposition 2 holds even without the condition of the strategic substitute.

[8] We can relax this assumption. Our results hold if $C'' - P' > 0$ for all q_1 and q_2 as long as $P > 0$.

uously differentiable, increasing, and strictly convex for $x_i > 0$. We further assume that $K(0) = K'(0) = 0$. This assumption guarantees that the social optimal level of abatement is never zero, and guarantees that the profit function is smooth.[9]

We examine the following three-stage game. In the first stage, firms non-cooperatively or cooperatively commit to their emission caps. In the non-cooperative ECSR choice case, each firm i independently chooses T_i to maximize its own profit. In the cooperative ECSR choice case, the industry association chooses $T_1 = T_2 = T$ to maximize joint profits. In the second stage, the firms face quantity competition. In the third stage, the firms engage in emission abatement activities.[10]

3 Quantity Competition

We solve the game by backward induction. First, we discuss the abatement activity. Because firms commit to the emission cap restriction,

$$x_i = \max\{g(q_i) - T_i, 0\}. \tag{1}$$

Next, we discuss the second-stage quantity competition, given T_1 and T_2. The firms choose their quantities independently, given T_1 and T_2. Let $q_i^{SQ}(T_i, T_j)$ (**s**econd-stage game equilibrium output under **q**uantity competition) be the equilibrium output of firm i ($i = 1, 2,\ i \neq j$).

There are three possible cases: (i) neither firm faces the emission cap restriction (i.e. $x_1 = x_2 = 0$), (ii) both firms are under the constraint (i.e. $x_1 x_2 > 0$), and (iii) only one firm, firm i, operates under the emission restriction (i.e. $x_i > 0$ and $x_j = 0$).

First, we consider case (i). The profit of firm $i = 1, 2$ for $g(q_i) \leq T_i$ is $\Pi_i(q_i, q_j) = P(Q)q_i - C(q_i)$. Let the superscript UQ denote the equilibrium outcome of this case

[9] As discussed later, marginal cost is C' when the constraint is not binding and $C' + K'g'$ when it is binding. The assumption guarantees $C = C + K$ and $C' = C' + K'g'$ when $g(q_i) - x_i = T_i$.

[10] The second and third stages are interchangeable in our analysis. If x_i is chosen before q_i, firm i chooses q_i such that $T_i = g(q_i) - x_i$ as long as the constraint $g(q_i) - x_i \leq T_i$ is binding. Thus, firm i chooses x_i taking account into the effect on its output. However, the resulting x and q are identical.

(**u**nconstrained **q**uantity competition). The equilibrium output, q^{UQ}, is characterized by the following first-order condition:

$$\frac{\partial \Pi_i}{\partial q_i} = P'(Q)q_i + P(Q) - C'(q_i) = 0 \ (i = 1, 2, \ i \neq j). \tag{2}$$

The second-order condition $2P' + P'q_i - C'' < 0$ is satisfied. The equilibrium is unique, stable, and symmetric under the assumptions we made in the previous section.[11] If $T_i \geq T^{UQ} := g(q^{UQ})$ $(i = 1, 2)$, $x_1 = x_2 = 0$, and thus, we regard no firm as adopting ECSR.

Second, we consider case (ii). As long as the emission cap constraint is binding, the profit function is $\Pi_i(q_i, q_j, T_i) = P(Q)q_i - C(q_i) - K(g(q_i) - T_i)$. The first-order condition is

$$\frac{\partial \Pi_i}{\partial q_i} = P'q_i + P - C' - K'g' = 0 \ (i = 1, 2, \ i \neq j). \tag{3}$$

The second-order condition and the stability condition are satisfied. Thus, unique equilibrium exists and is stable.

Differentiating (3) leads to

$$\frac{dq_i^{SQ}}{dT_i} = -\frac{(\partial^2 \Pi_i/\partial q_i \partial T_i)(\partial^2 \Pi_j/\partial q_j^2)}{(\partial^2 \Pi_i/\partial q_i{}^2)(\partial^2 \Pi_j/\partial q_j{}^2) - (\partial^2 \Pi_i/\partial q_i \partial q_j)(\partial^2 \Pi_j/\partial q_j \partial q_i)} > 0, \tag{4}$$

$$\frac{dq_j^{SQ}}{dT_i} = \frac{(\partial^2 \Pi_i/\partial q_i \partial T_i)(\partial^2 \Pi_j/\partial q_j \partial q_i)}{(\partial^2 \Pi_i/\partial q_i{}^2)(\partial^2 \Pi_j/\partial q_j{}^2) - (\partial^2 \Pi_i/\partial q_i \partial q_j)(\partial^2 \Pi_j/\partial q_j \partial q_i)} < 0, \tag{5}$$

where we use $\partial^2 \Pi_i/\partial q_i \partial T_i = K''g' > 0$, the second-order condition $(\partial^2 \Pi_i/\partial q_i^2 = 2P' + P''q_i - C'' - K''(g')^2 - K'g'' < 0)$, and the stability condition $((\partial^2 \Pi_i/\partial q_i{}^2)(\partial^2 \Pi_j/\partial q_j{}^2) - (\partial^2 \Pi_i/\partial q_i \partial q_j)(\partial^2 \Pi_j/\partial q_j \partial q_i) = (2P' + P''q_i - C'' - K''(g')^2 - K'g'')(2P' + P''q_j - C'' - K''(g')^2 - K'g'') - (P' + P''q_i)(P' + P''q_j) > 0)$. The second-order condition and the stability condition are satisfied under the standard assumptions we made in Section 2.

An increase in T_i increases q_i because it reduces firm i's marginal cost $C' + K'g'$, which indirectly reduces q_j through the strategic interaction. Furthermore, because $|\partial^2 \Pi_j/\partial q_j^2| = |2P' + P'q_j - C'' - K''g' - K'g''| > |\partial^2 \Pi_j/\partial q_j \partial q_i| = |P' + P'q_j|$, we obtain $dq_i^{SQ}/dT_i + dq_j^{SQ}/dT_i > 0$ (the direct effect dominates the indirect effect through strategic interaction).

[11] See Vives (1999).

Third, we consider case (iii). In this case, the equilibrium outputs are characterized by

$$\frac{\partial \Pi_i}{\partial q_i} = P'q_i + P - C' - K'g' = 0, \tag{6}$$

$$\frac{\partial \Pi_j}{\partial q_j} = P'q_j + P - C' = 0 \quad (j \neq i) \tag{7}$$

In this case, the equilibrium outputs depend only on T_i. Differentiating (6) and (7) leads to

$$\frac{dq_i^{SQ}}{dT_i} = -\frac{(\partial^2\Pi_i/\partial q_i \partial T_i)(\partial^2\Pi_j/\partial q_j^2)}{(\partial^2\Pi_i/\partial q_i{}^2)(\partial^2\Pi_j/\partial q_j{}^2) - (\partial^2\Pi_i/\partial q_i \partial q_j)(\partial^2\Pi_j/\partial q_j \partial q_i)} > 0 \tag{8}$$

$$\frac{dq_j^{SQ}}{dT_i} = \frac{(\partial^2\Pi_i/\partial q_i \partial T_i)(\partial^2\Pi_j/\partial q_j \partial q_i)}{(\partial^2\Pi_i/\partial q_i{}^2)(\partial^2\Pi_j/\partial q_j{}^2) - (\partial^2\Pi_i/\partial q_i \partial q_j)(\partial^2\Pi_j/\partial q_j \partial q_i)} < 0. \tag{9}$$

Again, an increase in T_i directly increases q_i and reduces q_j through the strategic interaction. Furthermore, because $|\partial^2\Pi_j/\partial q_j^2| = |2P' + P'q_j - C''| > |\partial^2\Pi_j/\partial q_j \partial q_i| = |P' + P'q_j|$, we obtain $dq_i^{SQ}/dT_i + dq_j^{SQ}/dT_i > 0$ (the direct effect dominates the indirect effect through strategic interaction).

We now consider the model in which each firm i independently chooses T_i to maximize its own profit. Let the superscript NQ denote the equilibrium outcome of this game (**N**on-cooperative ECSR choice under **q**uantity competition). We show that cases (ii) and (iii) never appear in equilibrium, and thus, emission cap constraint is not binding in equilibrium.

Suppose that the constraint for firm i is binding in equilibrium, and thus, $x_i > 0$.

$$\frac{\partial \Pi_i}{\partial T_i} = \frac{\partial \Pi_i}{\partial q_i}\frac{dq_i^{SQ}}{dT_i} + \frac{\partial \Pi_i}{\partial q_j}\frac{dq_j^{SQ}}{dT_i} + K' > 0 \quad (i = 1, 2,\ i \neq j), \tag{10}$$

where we use $\partial \Pi_i/\partial q_i = 0$ (first-order condition), $\partial \Pi_i/\partial q_j = P'q_i < 0$, $dq_j^{SQ}/dT_i < 0$, and $K' > 0$. Thus, a marginal increase in T_i increases firm i's profit as long as the constraint is binding. This implies that cases (ii) and (iii) never appear in equilibrium. These discussions lead to the following proposition.

Proposition 1 *Under quantity competition, no firm individually adopts ECSR (i.e. $x^{NQ} = 0$).*

Next, we consider the model in which the industry association chooses $T = T_1 = T_2$ to maximize the industry profit. Let the superscript CQ denote the equilibrium outcome of this game (**C**ooperative ECSR choice under **q**uantity competition).

We show that $T^{CQ} < T^{UQ}$, and thus, case (ii) appears in equilibrium by showing that a marginal decrease in T from T^{UQ} increases the joint profit. Note that the joint profit remains unchanged for $T \geq T^{UQ}$ because any $T \geq T^{UQ}$ yields the same outcome $(q_1, q_2) = (q^{UQ}, q^{UQ})$.

For $T \leq T^{UQ}$, we have

$$\frac{\partial(\Pi_1 + \Pi_2)}{\partial T}\Big|_{T=T^{UQ}} = 2\frac{\partial \Pi_1}{\partial T}\Big|_{T=T^{UQ}} = 2\frac{\partial \Pi_1}{\partial q_2}\Big(\frac{dq_2^{SQ}}{dT_1} + \frac{dq_2^{SQ}}{dT_2}\Big) < 0, \tag{11}$$

where we use $\partial \Pi_1/\partial q_1 = 0$ (first-order condition), $\partial \Pi_1/\partial q_2 = P' q_1 < 0$, $dq_2^{SQ}/dT_1 + dq_2^{SQ}/dT_2 > 0$ (direct effect dominates indirect effect), and $K'(0) = 0$ (Note that $x_i = 0$ when $T = T^{UQ}$). Thus, a marginal decrease in T_i from T^{UQ} increases the joint profit. In other words, $T \geq T^{UQ}$ is never optimal for the industrial association. These discussions lead to the following proposition.

Proposition 2 *Under quantity competition, the industry association adopts ECSR (i.e. $T^{CQ} < T^{UQ}$, and thus, $x^{CQ} > 0$).*

A marginal decrease in $T_1(T_2)$ from T^{UQ} decreases firm 1's (firm 2's) profit by the second order (envelope theorem), whereas a marginal decrease in $T_2(T_1)$ from T^{UQ} increases firm 1's (firm 2's) profit by the first order. Therefore, a simultaneous decrease in T_1 and T_2 increases the joint profits.

Propositions 1 and 2 indicate that the industry association plays a crucial role in adopting ECSR. Although the firms have no incentive to adopt ECSR, they accept ECSR coordinated by the industry association because it serves as a collusive device that restricts their output, resulting in a higher price.

Finally, we discuss the welfare implications of ECSR. Total social surplus (firm profits plus consumer surplus minus the loss caused by the externality) is given by

$$W = \int_0^Q P(z)dz - \sum_{i=1}^{2} [C(q_i) + K(x_i)] - \eta\Big(\sum_{i=1}^{2} [g(q_i) - x_i]\Big),$$

where $\eta : \mathbb{R}_+ \mapsto \mathbb{R}_+$ is the welfare loss of emissions. We assume that η is twice continuously differentiable, increasing, and convex.

Suppose that the government can choose $T = T_1 = T_2 \leq T^{UQ}$. Given the Cournot competition in the second stage, W is denoted by the following function.

$$W(T) = \int_0^Q P(z)dz - \sum_{i=1}^{2} [C(q_i^{SQ}) + K(g(q_i^{SQ}) - T)] - \eta(2T).$$

We obtain

$$\frac{\partial W}{\partial T} = 2\Big(-P' q_1^{SQ}\Big(\frac{dq_1^{SQ}}{dT_1} + \frac{dq_2^{SQ}}{dT_1}\Big) + K' - \eta'\Big), \tag{12}$$

where we use (3). The first term in (12) represents the welfare-improving effect of output expansion caused by a lesser degree of ECSR ($-P'q_1$ is equal to price-cost margin $P - C' - K'g'$). The second term represents the abatement cost-saving effect. The third term represents the welfare loss caused by an increase in emissions. The sign of the derivative at $T = T^{CQ}$ is negative if η' is large enough. In this case, T^{CQ} ($< T^{UQ}$) is still too large from the viewpoint of social welfare, and it implies that ECSR by industry association improves welfare as long as $W(T)$ is concave. Note that each firm chooses $T = T^{UQ}$ without the industry association. However, if η' is sufficiently small, (12) is positive and the degree of ECSR adopted by the industry association is too high for social welfare (i.e. the loss of collusive behavior dominates the emission-reducing effect).

4 Price Competition

We now consider Bertrand competition with product differentiation.[12] Assume there are two symmetric firms which produce differentiated products. The direct demand function

[12]Without product differentiation, there is no pure strategy equilibrium in our setting.

for product i is given by $D_i(P) : \mathbb{R}_+ \mapsto \mathbb{R}_+$ where $P := (p_1, p_2) \in \mathbb{R}^2_+$ is the price vector. We assume that D is twice continuously differentiable for all $P > 0$. The demand is downward sloping, $\partial D_i/\partial p_i < 0, i = 1, 2,$ and $\partial D_i/\partial p_j > 0, j \neq i$ as long as $D > 0$. The latter condition means that goods are substitutes. In addition, we assume that the direct effect of a price change dominates the indirect effect, $\sum_{j=1}^{2} (\partial D_i/\partial p_j) < 0$ and $\partial^2 D_i/(\partial p_i)^2 + |\partial^2 D_i/\partial p_i \partial p_j| < 0$. We further assume that demands have increasing differences in (p_i, p_j), $\partial^2 D_i/\partial p_i \partial p_j \geq 0$, which implies that the price setting game is supermodular. These are standard assumptions in the literature on Bertrand competition in differentiated product markets.[13] Except for the demand system, we follow the same structure in the quantity competition analysis.

The emission abatement level x_i is the same as that in the previous section. Here, we discuss the second-stage price competition. The firms choose their prices independently, given T_1 and T_2. Let $p_i^{SP}(T_i, T_j)$ (**s**econd-stage game equilibrium outcome under **p**rice competition) be the equilibrium price of firm i ($i = 1, 2,\ i \neq j$). Similar to the quantity competition analysis, there are three possible cases: (i) neither firm faces the emission cap restriction, (ii) both firms are under the constraint, and (iii) only one firm, firm i, operates under the emission restriction.

First, consider case (i). The profit of firm i for $g(q_i) \leq T_i$ is $\Pi_i(p_i, p_j) = p_i D_i(P) - C(D_i(P))$. Let the superscript UP denote the equilibrium outcome of this case (**u**nconstrained **p**rice competition). The equilibrium price, p_i^{UP}, is characterized by the following first-order condition:

$$\frac{\partial \Pi_i}{\partial p_i} = D_i(P) + p_i \frac{\partial D_i}{\partial p_i} - C' \frac{\partial D_i}{\partial p_i} = 0 \ (i = 1, 2,\ i \neq j). \tag{13}$$

We assume that the second-order condition

$\partial D_i/\partial p_i + (1 - (\partial D_i/\partial p_i)C'')\, \partial D_i/\partial p_i + (p_i - C')\partial^2 D_i/\partial p_i^2 < 0$ is satisfied.[14] Then, a unique,

[13] See Vives (1999).

[14] The second-order condition might not be satisfied if $\partial^2 D_i/\partial p_i^2$ is positive and quite large, which is satisfied in the case of extremely convex demand. We rule out such a case by imposing the second-order

stable, and symmetric equilibrium exists. If $T_i \geq T^{UP} := g(D_i(P^{UP}))$ $(i = 1, 2)$, $x_1 = x_2 = 0$, and thus, we regard no firm as adopting ECSR.

Second, we consider case (ii). As long as the emission cap constraint is binding, the profit function is $\Pi_i(p_i, p_j, T_i) = p_i D_i(P) - C(D_i(P)) - K\left(g\left(D_i(P)\right) - T_i\right)$. The first-order condition is

$$\frac{\partial \Pi_i}{\partial p_i} = D_i(P) + p_i \frac{\partial D_i}{\partial p_i} - C' \frac{\partial D_i}{\partial p_i} - K' g' \frac{\partial D_i}{\partial p_i} = 0 \ (i = 1, 2, \ i \neq j). \tag{14}$$

The second-order condition and the stability condition are satisfied.[15] Thus, the unique equilibrium exists and is stable.

Differentiating (14) leads to

$$\begin{aligned} \frac{dp_i^{SP}}{dT_i} &= -\frac{(\partial^2 \Pi_i/\partial p_i \partial T_i)(\partial^2 \Pi_j/\partial p_j^2)}{(\partial^2 \Pi_i/\partial {p_i}^2)(\partial^2 \Pi_j/\partial {p_j}^2) - (\partial^2 \Pi_i/\partial p_i \partial p_j)(\partial^2 \Pi_j/\partial p_j \partial p_i)} \\ &< 0, \end{aligned} \tag{15}$$

$$\frac{dp_j^{SP}}{dT_i} = \frac{(\partial^2 \Pi_i/\partial p_i \partial T_i)(\partial^2 \Pi_j/\partial p_j \partial p_i)}{(\partial^2 \Pi_i/\partial {p_i}^2)(\partial^2 \Pi_j/\partial {p_j}^2) - (\partial^2 \Pi_i/\partial p_i \partial p_j)(\partial^2 \Pi_j/\partial p_j \partial p_i)} < 0, \tag{16}$$

where we use $\partial^2 \Pi_i/\partial p_i \partial T_i = (\partial D_i/\partial p_i) K' g' < 0$, the second-order condition $(\partial^2 \Pi_i/\partial p_i^2 = \partial D_i/\partial p_i + (1 - (C'' + K''(g')^2 + K' g'')(\partial D_i/\partial p_i)) \partial D_i/\partial p_i + (p_i - C' - K' g') \partial^2 D_i/\partial p_i^2 < 0)$, and the stability condition $((\partial^2 \Pi_i/\partial {p_i}^2)(\partial^2 \Pi_j/\partial {p_j}^2) - (\partial^2 \Pi_i/\partial p_i \partial p_j)(\partial^2 \Pi_j/\partial p_j \partial p_i) > 0)$.

An increase in T_i decreases p_i because it reduces firm i's marginal cost $C' + K' g'$, which indirectly reduces p_j through the strategic interaction.

Third, we consider case (iii). In this case, the equilibrium prices are characterized by

$$\frac{\partial \Pi_i}{\partial p_i} = D_i(P) + p_i \frac{\partial D_i}{\partial p_i} - C' \frac{\partial D_i}{\partial p_i} - K' g' \frac{\partial D_i}{\partial p_i} = 0, \tag{17}$$

$$\frac{\partial \Pi_j}{\partial p_j} = D_i(P) + p_i \frac{\partial D_i}{\partial p_i} - C' \frac{\partial D_i}{\partial p_i} = 0 \ \ (j \neq i) \tag{18}$$

condition.

[15]We show that the stability condition is satisfied in the Appendix.

In this case, the equilibrium prices depend only on T_i. Differentiating (17) and (18) leads to

$$\frac{dp_i^{SP}}{dT_i} = -\frac{(\partial^2\Pi_i/\partial p_i\partial T_i)(\partial^2\Pi_j/\partial p_j^2)}{(\partial^2\Pi_i/\partial {p_i}^2)(\partial^2\Pi_j/\partial {p_j}^2) - (\partial^2\Pi_i/\partial p_i\partial p_j)(\partial^2\Pi_j/\partial p_j\partial p_i)} < 0, \tag{19}$$

$$\frac{dp_j^{SP}}{dT_i} = \frac{(\partial^2\Pi_i/\partial p_i\partial T_i)(\partial^2\Pi_j/\partial p_j\partial p_i)}{(\partial^2\Pi_i/\partial {p_i}^2)(\partial^2\Pi_j/\partial {p_j}^2) - (\partial^2\Pi_i/\partial p_i\partial p_j)(\partial^2\Pi_j/\partial p_j\partial p_i)} < 0. \tag{20}$$

Again, an increase in T_i decreases p_i and indirectly reduces p_j through the strategic interaction.

We now consider the model in which each firm i independently chooses T_i to maximize its own profit. Let the superscript NP denote the equilibrium outcome of this game (**N**on-cooperative ECSR choice under **p**rice competition). We show that cases (i) and (iii) never appear in equilibrium, and thus, emission cap constraint is binding for both firms.

Suppose that the constraint for firm i is not binding in equilibrium, and thus, $x_i = 0$.

$$\frac{\partial\Pi_i}{\partial T_i} = \frac{\partial\Pi_i}{\partial p_i}\frac{dp_i^{SP}}{dT_i} + \frac{\partial\Pi_i}{\partial p_i}\frac{dp_j^{SP}}{dT_i} + K' < 0 \ (i = 1, 2, \ i \neq j), \tag{21}$$

where we use $\partial\Pi_i/\partial p_i = 0$ (first-order condition), $\partial\Pi_i/\partial p_j = (p_i - C' - K'g')\partial D_i/\partial p_j > 0$, $dp_j^{SQ}/dT_i < 0$, and $K'(0) = 0$. Thus, a marginal decrease in T_i increases firm i's profit as long as the constraint is not binding. This implies that cases (i) and (iii) never appear in equilibrium. These discussions lead to the following proposition.

Proposition 3 *Under Bertrand competition, firms non-cooperatively adopt ECSR (i.e.* $x^{NP} > 0$*).*

In contrast to the quantity competition model, each firm voluntarily adopts ECSR, which increases its marginal costs of production. An increase in the production cost of firm i raises firm i's price as well as its rival's price through strategic interaction, resulting in an increase in firm i's profit.

We now compare the cooperative and non-cooperative cases under price competition. We consider the model in which the industry association chooses $T = T_1 = T_2$ to maximize the industry profit. If $T \geq T^{UP}$, $x_1 = x_2 = 0$ and prices of both firms do not depend on T. Thus, the joint profits do not depend on T. We assume that for $T \leq T^{UP}$, joint profit is concave with respect to T.

Let the superscript CP denote the equilibrium outcome of this game (**C**ooperative ECSR choice under **p**rice competition). We show that $T^{CP} < T^{NP}$ is in equilibrium by showing that a marginal decrease in T from T^{NP} increases joint profits.

We obtain

$$\begin{aligned} \frac{\partial(\Pi_1 + \Pi_2)}{\partial T}\Big|_{T=T^{NP}} &= 2\frac{\partial \Pi_1}{\partial T}\Big|_{T=T^{NP}} \\ &= 2\left(\frac{\partial \Pi_1}{\partial p_2}\Big(\frac{dp_2^{SQ}}{dT_1} + \frac{dp_2^{SQ}}{dT_2}\Big) + K'\right) = 2\frac{\partial \Pi_1}{\partial p_2}\frac{dp_2^{SQ}}{dT_2} < 0, \end{aligned} \tag{22}$$

where we use $\partial \Pi_i/\partial p_i = 0$ (first-order condition), $\partial \Pi_i/\partial p_j = (p_i - C' - K'g')\partial D_i/\partial p_j > 0$, $dp_i^{SQ}/dT_i < 0$, and $(\partial \Pi_i/\partial p_j)(dp_j^{SP}/dT_i) + K' = 0$ when $T_i = T^{NP}$. Thus, the marginal decrease in T_i from T^{NP} increases the joint profit. This implies that T^{NP} is too large from the joint-profit-maximizing viewpoint. These discussions lead to the following proposition.

Proposition 4 *Under price competition, the industry association adopts a higher level of ECSR (i.e. $T^{CP} < T^{NP} < T^{UP}$, and thus, $x^{CP} > x^{NP} > 0$).*

A decrease in T_i raises the price of firm i and increases the profit of firm j. When individual firm i chooses T_i, firm i considers its own profit only and does not take into account this rival's profit-raising effect. Thus, T^{NP} is too large from the viewpoint of joint profit maximization.

We obtain similar welfare implications under quantity competition. When the degree of negative externality of emissions is large, even T^{CP} is too large for social welfare. However, when the degree of negative externality of emissions is small, even $T^{NP} (> T^{CQ})$ is too small for social welfare. In short, ECSR can be either beneficial or harmful for social welfare.

5 ECSR by Emission Standard

In this section, we consider ECSR by the emission standard commitment. For simplicity, we assume that without abatement activity, the emission level is proportional to the output level, that is $g(q_i) = \alpha q_i$. We normalize $\alpha = 1$. Note that this specification satisfies the assumptions made in the previous sections.

Firm i $(i = 1, 2)$ adopts the emission standard $t_i \in [0, 1]$ and commits to $(q_i - x_i)/q_i \leq t_i$. We regard firm i as adopting ECSR if $t_i < 1$.

First, we consider quantity competition. In the third stage, each firm i chooses

$$x_i = (1 - t_i)q_i. \tag{23}$$

We discuss the second-stage quantity competition. The firms choose their quantities independently, given t_i and t_j. The profit of firm $i = 1, 2$ is $\Pi_i(q_i, q_j, t_i) = P(Q)q_i - C(q_i) - K\left((1 - t_i)\, q_i\right)$. Let $q_i^{SQ}(t_i, t_j)$ be the equilibrium output of firm i $(i = 1, 2,\ i \neq j)$ in this subgame. The equilibrium output, q_i^{SQ}, is characterized by the following first-order condition:

$$\frac{\partial \Pi_i}{\partial q_i} = P'(Q)q_i + P(Q) - C'(q_i) - (1 - t_i)K' = 0 \ (i = 1, 2,\ i \neq j). \tag{24}$$

The second-order condition and the stability condition are satisfied under the assumptions discussed in Section 3. Thus, unique equilibrium exists and is stable.

Differentiating (24) leads to

$$\begin{aligned}\frac{dq_i^{SQ}}{dt_i} &= -\frac{(\partial^2\Pi_i/\partial q_i \partial t_i)(\partial^2\Pi_j/\partial q_j^2)}{(\partial^2\Pi_i/\partial {q_i}^2)(\partial^2\Pi_j/\partial {q_j}^2) - (\partial^2\Pi_i/\partial q_i \partial q_j)(\partial^2\Pi_j/\partial q_j \partial q_i)} \\ &> 0,\end{aligned} \tag{25}$$

$$\begin{aligned}\frac{dq_j^{SQ}}{dt_i} &= \frac{(\partial^2\Pi_i/\partial q_i \partial t_i)(\partial^2\Pi_j/\partial q_j \partial q_i)}{(\partial^2\Pi_i/\partial {q_i}^2)(\partial^2\Pi_j/\partial {q_j}^2) - (\partial^2\Pi_i/\partial q_i \partial q_j)(\partial^2\Pi_j/\partial q_j \partial q_i)} \\ &< 0,\end{aligned} \tag{26}$$

where we use $\partial^2\Pi_i/\partial q_i \partial t_i = K' + (1-t_i)K'' q_i > 0$, the second-order condition ($\partial^2\Pi_i/\partial {q_i}^2 = 2P' + P'' q_i - C'' - (1-t_i)^2 K'' < 0$), and the stability condition $((\partial^2\Pi_i/\partial {q_i}^2)(\partial^2\Pi_j/\partial {q_j}^2) - (\partial^2\Pi_i/\partial q_i \partial q_j)(\partial^2\Pi_j/\partial q_j \partial q_i) = (P'' q_i + 2P' - C'' - (1-t_i)^2 K'')(P'' q_j + 2P' - C'' - (1-t_i)^2 K'') - (P'' q_i + P')(P'' q_j + P') > 0)$. Furthermore, because $|\partial^2\Pi_j/\partial q_j^2| = |2P' + P' q_j - C'' - (1-t_j)^2 K''| > |\partial^2\Pi_j/\partial q_j \partial q_i| = |P' + P' q_j|$, we obtain $dq_i^{SQ}/dt_i + dq_j^{SQ}/dt_i \geq 0$ (the direct effect dominates the indirect effect through strategic interaction).

We now highlight one important property. Because $K'(0) = 0$ and $x_i = 0$ when $t_i = 1$, $\partial^2\Pi_i/\partial q_i \partial t_i = K' + (1-t_i)K'' q_i = 0$ when $t_i = 1$. Thus, we obtain $dq_i^{SQ}/dt_i = dq_j^{SQ}/dt_i = 0$ when $t_i = 1$.

We now discuss the first-stage action. First, we consider the model in which each firm i individually chooses t_i to maximize its own profit. Again, the superscript NQ denote the equilibrium outcome under non-cooperative choice of ECSR.

For any $t_i \in [0, 1)$, we obtain

$$\frac{\partial \Pi_i}{\partial t_i} = \frac{\partial \Pi_i}{\partial q_i}\frac{dq_i^{SQ}}{dt_i} + \frac{\partial \Pi_i}{\partial q_j}\frac{dq_j^{SQ}}{dt_i} + K' q_i^{SQ} > 0, \ (i = 1, 2, \ i \neq j), \tag{27}$$

where we use $\partial\Pi_i/\partial q_i = 0$, $\partial\Pi_i/\partial q_j = P' q_i < 0$, $dq_j^{SQ}/dt_i < 0$, and $K' q_i^{SQ} > 0$. Therefore, each firm chooses $t_i = 1$. These discussions lead to the following proposition.

Proposition 5 *Under quantity competition with emission standard commitment, no firm individually adopts ECSR (i.e. $t_i = 1$, and thus, $x^{NQ} = 0$).*

Next we consider the model in which the industry association chooses $t = t_i = t_j$ to maximize the joint profit. We assume that joint profit is concave in t_i. Again, let the superscript CQ denote the equilibrium outcome of this cooperative choice of ECSR. We obtain

$$\left.\frac{\partial(\Pi_i + \Pi_j)}{\partial t}\right|_{t=1} = 2\frac{\partial \Pi_i}{\partial t} = 2\left(\frac{\partial \Pi_i}{\partial q_j}\left(\frac{dq_j^{SQ}}{dt_i} + \frac{dq_j^{SQ}}{dt_j}\right) + K' q_i^{SQ}\right) = 0, \tag{28}$$

where we use $dq_i^{SQ}/dt_i = dq_j^{SQ}/dt_i = 0$, $x = 0$, and $K'(0) = 0$ when $t = 1$. This implies that $t = 1$ is optimal. This leads to the following proposition.

Proposition 6 *Under quantity competition with emission standard commitment, even the industry association does not adopt ECSR (i.e. $t = 1$, and thus, $x^{CQ} = 0$).*

Some readers might consider that the assumption that joint profit is concave in t is restrictive. We show that

$$\left.\frac{\partial(\Pi_i + \Pi_j)}{\partial t}\right|_{t=1} = 0$$

but it might imply that $t = 1$ yields locally minimized joint profits rather than maximized ones if the abovementioned assumption is not satisfied. However, it is quite difficult to derive a clear condition guaranteeing this assumption. We now present an example satisfying this assumption.

Suppose that demand is linear ($P = a - Q$), marginal cost is constant and is normalized to zero, and the abatement cost function is quadratic ($K = kx_i^2/2$). Then, we obtain

$$\frac{\partial(\Pi_i + \Pi_j)}{\partial t} = \frac{2\alpha^2 k(1-t)\,(1 + k(1-t)^2)}{(3 + k(1-t)^2)^3}. \tag{29}$$

This is positive for $t \in [0, 1)$ and zero when $t = 1$. Thus, $t = 1$ (no ECSR) maximizes the joint profits.

Proposition 6 is in sharp contrast to Proposition 1. Even the industry association that maximizes joint profit does not adopt ECSR.[16] Under the emission standard commitment, firm i can emit $t_i q_i$, whereas under the emission cap commitment, the firm can emit T_i independently of q_i. Thus, each firm has a stronger incentive to expand its output under the emission standard commitment. Therefore, the output-restricting effect of ECSR is weaker under the emission standard commitment.

This result suggests that ECSR by emission standard is less likely to restrict competition. If the emission standard is adopted by the industry association, it is more likely to be for the purposes of benevolence or improvement of industry image, like advertising, and not for the purpose of enhancing collusion.

[16] Firms do not choose ECSR when each firm i chooses t_i independently.

We show that under price competition, we obtain a similar result to Proposition 6. That is, as long as the joint profit is concave with respect to t, $t = 1$ yields joint profit maximization. While the assumption of concavity might be too restrictive, it is quite difficult to derive a clear condition guaranteeing this assumption. We now present an example satisfying this assumption.

Suppose that the demand is given by $p_i = \alpha - \beta q_i - 0.5\beta q_j$ $(i = 1, 2,\ i \neq j)$, then marginal cost is constant and is normalized to zero, and the abatement cost function is quadratic $K = kx_i^2/2$. Then, we obtain

$$\frac{\partial(\Pi_i + \Pi_j)}{\partial t} = \frac{32\alpha^2 k\left(3\beta + 4k(1-t)^2\right)(1-t)}{\left(9\beta + 4k(1-t)^2\right)^3}. \tag{30}$$

This is positive for $t \in [0, 1)$ and zero when $t = 1$. Thus, in fact $t = 1$ (no ECSR) maximizes the joint profits.

6 Concluding Remarks

In this study, we demonstrate that profit-maximizing industry associations adopt ECSR even when it induces member firms to engage in unprofitable emission abatement activities. This cost increase raises prices or reduces quantities, resulting in an increase in industry profits. Therefore, ECSR can yield collusive behavior that reduces welfare, even though it reduces total emissions.

In addition, we show that whether the effect of restricting competition is significant depends on the type of ECSR. We show that the emission cap commitment has this effect, but the emission standard commitment does not.

One implication of this paper is the potential for ECSR to change investment in abatement technology or R&D. In particular, certain types of abatement technologies (different functional forms for $K(\cdot)$) may facilitate collusion. If firms respond to this incentive, then the anticompetitive effects of ECSR could exceed the one-shot losses explored in this paper.

A limitation of this study is that we neglect such environmental policies as emission taxes and tradable permits. ECSR may well reduce environmental taxes or relax environmental regulations, which would increase industry profits further. Introducing the government as an active player that implements environmental policies and investigating the relationship between these policies and ECSR are avenues left to future research.

A Stability condition under price competition

$$
\begin{aligned}
&\frac{\partial^2\Pi_i}{\partial {p_i}^2}\frac{\partial^2\Pi_j}{\partial {p_j}^2}-\frac{\partial^2\Pi_i}{\partial p_i\partial p_j}\frac{\partial^2\Pi_j}{\partial p_i\partial p_j}\\
&=\left(\frac{\partial D_i}{\partial p_i}+\left(1-\left(C''+K''(g')^2+K'g''\right)\frac{\partial D_i}{\partial p_i}\right)\frac{\partial D_i}{\partial p_i}+(p_i-C'-K'g')\frac{\partial^2 D_i}{\partial p_i^2}\right)\cdot\\
&\quad\left(\frac{\partial D_j}{\partial p_j}+\left(1-\left(C''+K''(g')^2+K'g''\right)\frac{\partial D_j}{\partial p_j}\right)\frac{\partial D_j}{\partial p_j}+(p_j-C'-K'g')\frac{\partial^2 D_j}{\partial p_j^2}\right)\\
&-\left(\left(1-\left(C''+K''(g')^2+K'g''\right)\frac{\partial D_i}{\partial p_i}\right)\frac{\partial D_i}{\partial p_j}+(p_i-C'-K'g')\frac{\partial^2 D_i}{\partial p_i\partial p_j}\right)\cdot\\
&\quad\left(\left(1-\left(C''+K''(g')^2+K'g''\right)\frac{\partial D_j}{\partial p_j}\right)\frac{\partial D_j}{\partial p_i}+(p_i-C'-K'g')\frac{\partial^2 D_j}{\partial p_i\partial p_j}\right)>0.
\end{aligned}
$$

References

Antweiler, Werner. (2003). 'How Effective Is Green Regulatory Threat?', *American Economic Review*, vol. 93(2), pp. 436–441.

Baron, D. P. (2008). 'Managerial contracting and corporate social responsibility', *Journal of Public Economics*, vol. 92(1–2), pp. 268–88.

Brand, B. and Grothe, M. (2015). 'Social responsibility in a bilateral monopoly', *Journal of Economics*, vol. 115(3), pp. 275–89.

Calveras, A., Ganuza, J.-J., and Llobet, G. (2007). 'Regulation, corporate social responsibility and activism', *Journal of Economics and Management Strategy*, vol. 16(3), pp. 719–40.

Carbon Disclosure Project (CDP). (2013). Use of internal carbon price by companies as incentive and strategic planning tool: A review of findings from CDP 2013 disclosure.

Cardwell, D. (2014). 'NRG seeks to cut 90% of its carbon emissions.' *New York Times*, (online) November 20. http://www.nytimes.com/2014/11/21/business/energy-environment/nrg-sets-goals-to-cut-carbon-emissions.html?_r=1.

Carroll, A. B. and Shabana, K. M. (2010). 'The business case for CSR: A review of concepts, research and practice', *International Journal of Management Reviews*, vol. 12(1), pp. 85–105.

Farzin, Y. H. (2003). 'The effects of emissions standards on industry', *Journal of Regulatory Economics*, vol. 24(3), pp. 315–27.

Goering, G. E. (2014). 'The profit-maximising case for corporate social responsibility in a bilateral monopoly', *Managerial and Decision Economics*, vol. 35(7), pp. 493–9.

Helfand, G. (1991). 'Standards versus standards: The effect of different pollution restrictions', *American Economic Review*, vol. 81(3), pp. 622–34.

Kitzmueller, M. and Shimshack, J. (2012). 'Economic perspectives on corporate social responsibility', *Journal of Economic Literature*, vol. 50(1), pp. 51–84.

KPMG. (2013). International Survey of Corporate Responsibility Reporting. KPMG International.

Lahiri, S. and Ono, Y. (2007). 'Relative emission standard versus tax under oligopoly: The role of free entry', *Journal of Economics*, vol. 91(2), pp. 107–28.

Lambertini, L. and Tampieriz, A. (2015). 'Incentives, performance and desirability of socially responsible firms in a Cournot oligopoly', *Economic Modelling*, vol. 50, pp. 40–8.

Lee, J. (2010). 'FTSE 100 carbon chasm', Report, Carbon Disclosure Project (CDP). https://www.cdproject.net/CDPResults/FTSE_100_Carbon_Chasm.pdf

Liu, C.-C., Wang, L. F. S., and Lee, S.-H. (2015). ‘Strategic environmental corporate social responsibility in a differentiated duopoly market’, *Economics Letters*, vol. 129, pp. 108–11.

Lyon, T. P. and Maxwell, J. W. (2004). *Corporate Environmentalism and Public Policy*, Cambridge University Press, Cambridge, UK.

Margolick, M. and Russell, D. (2001). ‘Corporate greenhouse gas reduction targets’, Reports, Global Change Strategies International, Inc.

Margolis, J. D., Elfenbein, H. A., and Walsh, J. P. (2007). ‘Does it pay to be good? A meta-analysis and redirection of research on the relationship between corporate social and financial performance’, Unpublished Working Paper, Ross School of Business, University of Michigan.

Maxwell, J. W., Lyon, T. P., and Hackett, S. C. (2000). ‘Self-regulation and social welfare: The political economy of corporate environmentalism’, *Journal of Law and Economics*, vol. 43(2), pp. 583–617.

McWilliams, A. and Siegel, D. S. (2001). ‘Corporate social responsibility: A theory of the firm perspective’, *Academy of Management Review*, vol. 26(1), pp. 117–27.

McWilliams, A., Siegel, D. S., and Wright, P. W. (2006). ‘Corporate social responsibility: Strategic implications’, *Journal of Management Studies*, vol. 43(1), pp. 1–18.

Vives, X. (1999). *Oligopoly Pricing: Old Idea and New Tools*, The MIT Press, Cambridge, Massachusetts, London, England.

Vogel, D. (2005). *The Market for Virtue: The Potential and Limits of Corporate Social Responsibility*. Brookings Institution Press, Washington, DC.