# Corporate Social Responsibility and Environmental Taxation with Endogenous Entry

Xu, Lili and Lee, Sang-Ho

Dalian Maritime University, China, Chonnam National University, Korea

1 April 2018

**Corporate Social Responsibility and Environmental Taxation with Endogenous Entry**

*Lili Xu* and* S*ang-Ho Lee***

* Lecturer, Department of Economics and Trade, Dalian Maritime University, Dailian, China. lilixuchonnam@hotmail.com.

** Corresponding author. Professor, Department of Economics, Chonnam National University, Gwangju, Korea. sangho@jnu.ac.kr.

**Abstract**

*This study considers Corporate Social Responsibility (CSR) in Cournot markets with endogenous entry and investigates the effects of CSR on environmental taxation and welfare consequences. We show that the optimal tax under free entry is higher than that under blockaded entry and also higher than marginal environmental damage. We then show that a higher taxation is socially excessive from the viewpoint of socially optimal CSR, which requires an appropriate regulatory framework for CSR promotion. Finally, we show that the environment is less damaged but social welfare deteriorates accompanied with CSR when the fixed cost is low, while pollution abatement activities will reduce the optimal tax and improves both environmental quality and social welfare.*

**Keywords:** consumer-friendly firm; corporate social responsibility; environmental tax; free entry; blockaded entry

**JEL classification:** L13; L31; Q5

## 1. Introduction

In recent decades, as the world's economy is moving towards higher levels of globalization and economic liberalization, the renewal of regulated markets which includes not only the abolition of entry restrictions but the creation of environmental protections has been extensively implemented. In practice, government has continuously conducted not only command-and-control environmental regulations such as best available technology standards and subsidies, but also market-based environmental regulations such as taxes and cap-and-trades.

Regarding environmental taxation, various studies have explored the effect of taxation in imperfect competition markets. In specific, in a blockaded entry market where the number of firms is fixed, the optimal tax rate is equal to the marginal environmental damage in perfect competition markets while it falls short of the marginal damage in imperfect competition markets. In a free-entry market where the number of firms is endogenously determined, however, the optimal tax might be higher (or lower) than the marginal environmental damage because the tax effect on the output can be offset by the effect on the number of entering firms.[1] Thus, under the liberalization policy the environmental tax can work for reducing excessive entry, which is caused by a business-stealing effect in an oligopolistic competition.[2]

Recently, corporate social responsibility (CSR) becomes much popular in the business economics, contrary to the traditional view of profit maximization as the sole objective of a private firm. Since the pioneering analysis of Porter and Kramer (2006), CSR has now become a mainstream global business strategy and a large number of firms in the world issue various CSR statements/activities.[3] GE's Ecomagination program, Nestle's Creating Shared Values, and Unilevel's Simple Living Plan are excellent examples. Nowadays, more and more firms are gradually adopting corporate self-disciplines that take more into account than profits, i.e., that regard ethical issues and community welfare as important business routines.

This aspect has also motivated the recent economic analysis of mixed oligopolies in which profit-oriented private firms compete with not-for profit firms. For example, regarding CSR-firm as a consumer-friendly firm, which cares for consumer surplus, Goering (2012, 2014) and Brand and Grothe

---

[1] See Katsoulacos and Xepapadeas (1995) and Lee (1999). In the subsequent research, it is proved that the optimal emission tax rate in free-entry markets depends on the curvature of market demand (Requate, 2007), the degree of product differentiation (Fujiwara, 2009), the output elasticity of emissions (Sugeta, 2017) and consumers awareness (Hsu *et al.*, 2017). However, all these analysis still support that the optimal tax can reduce excessive entry.

[2] There has been considerable interest in examining the excessive entry problem in the free entry oligopolistic markets since the pioneering studies by Mankiw and Whinston (1986) and Suzumura and Kiyono (1987). See, for example, Suzumura (2012) and Wang *et al.* (2014) reviewed the recent analysis on the excessive-entry theorem.

[3] According to KPMG (2013), nearly 92% of the 250 largest companies worldwide issued CSR reports and more than 30% (71% and 90%) of companies in the US (the UK and Japan, respectively) adopted CSR in 2013.

(2013, 2015) examined a vertical supply chain and Matsumura and Ogawa (2014) and Kopel and Brand (2014) analysed horizontal products differentiation. Also, Wang *et al.* (2012), Chang *et al.* (2014) and Liu *et al.* (2018) explored strategic tariff policy and Liu *et al.* (2015) and Leal *et al.* (2018) examined the environmental policy.

This paper extends their analysis of CSR-initiatives into the polluting industry with endogenous entry under environmental taxation. Our approach is different with the standard analysis of mixed oligopolies where private firms compete with a public firm in free entry markets.[4] Cato (2008) shows that nationalization policy is preferable to a privatization policy if the public firm earns positive profit, which also supports the result in Matsumura and Kanda (2005). But, they assume that the external costs vary exogenously with aggregate outputs and the public firm fully internalizes the environmental externality without considering environmental policy. On the contrary, our approach takes the analysis of Pal and Saha (2015), Xu *et al*. (2016) and Lee and Xu (2018), who examine the optimal emission tax when the public firm takes abatement activities but does not fully internalize the environmental externality. But, they concentrate on the blockaded entry markets and did not consider the liberalization policy on free entry markets.

In this paper, we emphasize the role of CSR-firm in free entry markets and investigate the impact of the CSR on the optimal environmental tax. The analysis delivers a simple result that the CSR-firm facing endogenous entry are always aggressive compared to the private firms and thus it produces larger output. This result is comparable with the analysis of Lambertini and Tampiere (2015) and Leal *et al.* (2018) under Cournot duopoly, who showed that CSR-firm produces larger output, which induces rivals to reduce their output. Thus, under blockaded entry a higher taxation than the marginal environmental damage can be optimal to the society when the firm adopts CSR activities too high. However, when entry is endogenous, a larger production of the CSR-firm leads to the small number of firms, which will reduce the excessive entry in free entry market. Further, a higher taxation can also reduce firm's output, but it can also indirectly increase firm's output by reducing the number of firms. Since the excessive entry problem can be significant, the optimal environmental tax will be higher than the marginal environmental damage even in the small degree of CSR.[5] However, we also show that a higher taxation is socially excessive from the viewpoint of socially optimal degree of CSR. This implies that an

---

[4] In the literature of mixed oligopolies, various studies have examined the welfare effect of privatization in a free-entry market and showed that the presence of a public firm can serve as an alternative to direct entry regulations in precluding excessive-entry problems. See, for example, Matsumura and Kanda (2005), Brandao and Castro (2007), Ino and Matsumura (2010), Cato and Matsumura (2012, 2015), Wang (2016), Xu *et al*. (2017) and Xu and Lee (2018).

[5] Note that the market role of CSR-firm to increase the output aggressively can be interpreted as that of Stackelberg leadership with dominant private or public firms. Regarding the output and welfare effects of the Stackelberg leadership, see Etro (2008) and Ino and Matsumura (2010, 2012).

appropriate regulatory framework is necessary for promoting CSR.

We also compare the result in the blockaded entry markets where the government can set entry regulations, and show that the optimal tax under free entry should be higher than that under blockaded entry. It implies that the socially excessive entry problem calls for a higher environmental taxation even with a CSR-firm, but it depends on the degree of CSR. Therefore, the active role of governmental guideline for CSR, rather than considering it on a voluntary basis, is necessary.[6] Finally, we show that the environment is less damaged but social welfare deteriorates accompanied with a CSR-firm when the fixed cost is low, while pollution abatement activities will reduce the optimal tax in free entry markets but improve environmental quality and social welfare.

The remainder of this paper is organized as follows. In Section 2, we introduce the basic model. In Section 3, we examine the optimal environmental tax in free entry markets. In Section 4, we compare and discuss the effects of CSR-firm on the optimal tax under entry regulation and pollution abatement activities, respectively. Section 5 concludes the analysis.

## 2. The model

We consider a mixed market with a CSR-firm and *n* private firms $(n > 0)$ producing homogeneous goods. Contrary to profit-maximizing private firms, a CSR-firm, denoted by firm 0, cares for not only its profits but also consumer surplus. The inverse demand function is linear, given by $P = A - Q$, where $P$ is the market price, $Q = q_0 + \sum_{i=1}^{n} q_i$ is the market output, and the amount of the good produced by firm $i$ is $q_i$, $i$ =1,2, ...,$n$. Without loss of generality, each firm has the same quadratic cost function,[7] $C(q_j) = \frac{1}{2} {q_j}^2 + F$, where $F$ is the fixed entry cost and $j$ =0,1, ...,$n$. Each unit of the good produced by firms creates one unit of pollutant (i.e., $e_j = q_j$). The government imposes an environmental tax $t$ per unit of pollutant emitted. Then, the profit function of firm $j$ is

$$\pi_j = Pq_j - \frac{1}{2} {q_j}^2 - F - tq_j. \tag{1}$$

---

[6] The promotion of CSR has become a top priority in the policy agenda for sustainable development in many countries and international organization. Further encouragement of CSR became a central policy objective in the United States and European Union. For example, the UK government website (http://www.csr.gov.uk/policy.shtml) stated that: "The Government can provide a policy and institutional framework that stimulates [socially responsible] companies to raise their performance [voluntarily] beyond minimum legal standards. Our approach is to encourage and incentivize the adoption of CSR, through best practice guidance, and, where appropriate, intelligent [soft-law] regulation and fiscal incentives." See also Steurer (2010).

[7] Since the pioneering study of De Fraja and Delbono (1989) in a mixed market, many researchers have assumed the same production efficiency between the firms. Matsumura and Kanda (2005) present some useful arguments on the increasing cost function.

We first consider free entry markets in a long-run equilibrium where private firms can enter a market without entry regulation. That is, the number of the private firms is determined at the point where the profit of the private firms is zero ($\pi_i = 0$) in a free-entry equilibrium.

We assume that the production process causes environmental pollution and each unit of the good produced by firms creates one unit of pollutant (i.e., $e_j = q_j$).[8] We use a linear environmental damage function, for the sake of analytic simplicity, $ED = dQ$, where $d$ denotes marginal environmental damage. The government imposes an environmental tax $t$ per unit of pollutant emitted and the tax revenue is defined as $T = tQ$. Then, if the environmental tax is equal to the marginal damage, i.e., $t = d$, the tax revenue is equal to the environmental damage.

The social welfare is defined as the sum of consumer surplus, total profits of firms, and tax revenue, minus environmental damage:

$$W = CS + \pi_0 + \sum_{i=1}^{n} \pi_i + T - ED, \tag{2}$$

where $CS = \frac{1}{2}Q^2$. We assume that a private firm seeks profit maximization, whereas a CSR-firm considers not only its own profits but also consumer surplus. That is, we assume that CSR initiative includes both profitability and consumer surplus, as a proxy of its own concern on consumers, and thus the objective of the CSR-firm is a combination of consumers surplus and its own profit:[9]

$$G = \pi_0 + \alpha CS, \tag{3}$$

where $\alpha \in [0,1]$ indicates the weight assigned to consumer. It is also interesting to note that when the environmental tax is equal to the marginal damage (i.e., $t = d$) and full consideration of consumer surplus (i.e., $\alpha = 1$), the social welfare in (2) equals the objective of the CSR-firm in (3) at the free entry equilibrium where all private firms earn zero profits.

The game runs as follows. In the first stage, the government sets the environmental tax before firms move. In the second stage, given $t$, each private firm decides whether to enter the market (the entry cost is sunk if a private firm enters the market), where the number of private firms is endogenously determined by a free-entry market condition (zero-profit condition). In the third stage, the firms compete compete in quantities in a Cournot fashion. We solve the game by backward induction to obtain a

[8] In Section 4.4, we consider the case that polluting firms can choose pollution abatement technology and examine how pollution abatement activities affect our results in a mixed market.

[9] This objective function shows that the firm takes its profit-maximizing decision under consumer-oriented consideration in which consumer surplus in the market does not fall below a fixed level. This formulation of the objective function is comparable with the mixed market where a public firm no longer internalizes environmental externalities in its objective function. For more discussion, see Barcena-Ruiz and Garzon (2006), Beladi and Chao (2006) and Xu *et al.* (2016).

subgame perfect Nash equilibrium. In the following analysis, we assume that $0 < F < \frac{3(2-\alpha)^2(A-d)^2}{2(6-3\alpha+\alpha^2)^2}$ in order to have interior solutions in the free-entry market.

**3. The analysis of free entry equilibrium**

In the third stage, firm 0 chooses its output level $q_o$ to maximize its objective function in (3), and private firms choose their output levels $q_i$ to maximize their own profits in (1). The first-order conditions are as follows:

$$\frac{\partial G}{\partial q_o} = A - t - 2q_o - (1-\alpha)(q_o + \textstyle\sum_{i=1}^{n} q_i) = 0\,, \tag{4}$$

$$\frac{\partial \pi_i}{\partial q_i} = A - t - q_o - \textstyle\sum_{i=1}^{n} q_i - 2q_i = 0. \tag{5}$$

Combining (4) and (5), the equilibrium outputs are

$$q_o = \frac{(2+n\alpha)(A-t)}{2(3+n-\alpha)} \quad \text{and} \quad q_i = \frac{(2-\alpha)(A-t)}{2(3+n-\alpha)}. \tag{6}$$

Note that firm 0 produces more outputs than those of private firm, i.e., $q_o > q_i$. Thus, when firm 0 cares for consumer surplus, it behaves more aggressively and the concern on consumer surplus expands the production. A higher emission tax will reduce the output of firm 0 while the effect of tax on the output of the private firm depends on the indirect effect on the number of firms. That is, a larger number of firms reduces the output of the private firm because of the business-stealing effect, but it will not affect the output of firm 0.

The equilibrium profits of the firms are

$$\pi_0 = \frac{(2+n\alpha)(6-\alpha(4+n))(A-t)^2}{8(3+n-\alpha)^2} - F,\ \ \pi_i = \frac{3(2-\alpha)^2(A-t)^2}{8(3+n-\alpha)^2} - F. \tag{7}$$

In the second stage, each private firm earns zero profit in the equilibrium. Under free-entry conditions where the profit of private firms in (7) is zero, we can obtain the equilibrium number of private firms:

$$n = \frac{(2-\alpha)(A-t)}{4}\sqrt{\frac{6}{F}} + \alpha - 3. \tag{8}$$

Note that private firms exist in a free-entry market only when the tax or/and fixed entry cost is small, i.e., $n > 0$ only if $0 < F < \frac{3(2-\alpha)^2(A-t)^2}{8(3-\alpha)^2}$. Then, we have that the number of private firms decreases with higher tax (or/and fixed cost) and higher degree of CSR, i.e., $\frac{\partial n}{\partial t} < 0$, $\frac{\partial n}{\partial F} < 0$ and $\frac{\partial n}{\partial \alpha} < 0$.

The equilibrium outputs of the firms and total market are as follows:

$$q_o = \frac{A-t}{2}\alpha + \frac{\sqrt{6F}}{3}(1-\alpha), \quad q_i = \frac{\sqrt{6F}}{3}, \quad Q = A - t - \frac{2\sqrt{6F}}{3}. \tag{9}$$

Note that the equilibrium output of the private firm is not affected by taxation. It implies that the direct effect of taxation to increase the output of the private firm in (6) will be cancelled out by the indirect effect of taxation imposed to decrease the number of firms in (8), which will indirectly reduce the output of the private firm in (6).

Finally, the profit of firm 0 is as follows:

$$\pi_0 = \frac{\sqrt{6F}\alpha(1+\alpha)(A-t)}{6} - \frac{(A-t)^2\alpha^2}{8} - \frac{\alpha(2+\alpha)}{3}F. \tag{10}$$

Note that firm 0 can survive in free entry markets, i.e., $\pi_0 \geq 0$, only when $F_0 \equiv \frac{3\alpha^2(A-t)^2}{8(2+\alpha)^2} \leq F < \frac{3(2-\alpha)^2(A-t)^2}{8(3-\alpha)^2}$ . Otherwise, it will earn negative profits and thus exit (or becomes profit-maximizing private firm) in the long-run, i.e., $\pi_0 < 0$ when $0 < F < F_0$. Note that $\frac{\partial F_0}{\partial \alpha} > 0$. Thus, a higher degree of CSR will reduce the survival range for the CSR-firm in free entry markets. Then, we have two market configuations, private market where firm 0 does not exist and mixed market where firm 0 exists, depending on the size of fixed cost.

### 3.1. Private market

When the fixed cost is small ($0 < F < F_0$), the CSR-frim does not exist in the long-run equilibrium. In a private oligopoly under free entry, we assume that *n+1* private firms compete in polluting market.[10] Using the first-order condition in (5), we have the equilibrium outputs and profits of private firms:

$$q_i = \frac{A-t}{3+n}, \quad Q = \frac{(1+n)(A-t)}{3+n}, \quad \pi_i = \frac{3(A-t)^2}{2(3+n)^2} - F. \tag{11}$$

Then, under free-entry conditions, where the profit of private firms in (11) is zero, we can obtain the equilibrium number of private firms

$$n = \frac{1}{2}(A-t)\sqrt{\frac{6}{F}} - 3. \tag{12}$$

The number of private firms is positive and it decreases as the tax or/and fixed (entry) cost increases.

Substituting the equilibrium number of private firms into (11), we derive the following equilibrium outputs:

[10] For the comparable results with Section 3.2 where a CSR-firm operates and the total number of firms in the market is $n+1$, we set the number of firms in a private oligopoly as $n+1$, instead of $n$.

$$q_i = \frac{\sqrt{6F}}{3}, \ Q = A - t - \frac{2\sqrt{6F}}{3}. \quad (13)$$

Note that each private firm's output is also independent of the level of the tax at equilibrium in a private oligopoly, i.e., $\frac{\partial q_i}{\partial t} = 0$. This is because the equilibrium output of the private firm is determined at the zero-profit condition, in which the equilibrium output is exactly the difference between the average cost and the marginal cost.[11] However, the environmental tax affects not only the number of firms but also the total market outputs.

The resulting consumer surplus, environmental damage, and social welfare are

$$CS = \frac{1}{2}\left(A - t - \frac{2\sqrt{6F}}{3}\right)^2, \ ED = d(A - t - \frac{2\sqrt{6F}}{3}),$$

$$W = \frac{1}{2}(A - t - \frac{2\sqrt{6F}}{3})(A + t - 2d - \frac{2\sqrt{6F}}{3}). \quad (14)$$

In the first stage, the government chooses the environmental tax to maximize its social welfare in (14). The optimal environmental tax is

$$t^P = d, \quad (15)$$

where superscript "P" denotes the equilibrium outcome of this free-entry private market. From equation (15), we obtain the following lemma.

**Lemma 1** *The optimal environmental tax is exactly determined at the level of marginal environmental damage in free entry private market where a CSR-firm does not exist.*

Lemma 1 represents that an environmental tax can be used not only to internalize environmental damage, but also to control the number of private firms. A higher taxation directly lowers the firm's output, it can also indirectly increase the firm's output by reducing the number of firms. And the direct effect of taxation on output and the indirect effect on output offset each other. This result is consistent with the previous result in Katsoulacos and Xepapadeas (1995) and Lee (1999) who showed that in a private market under free entry, the optimal environmental tax should be equal to marginal environmental damage.

Substituting the optimal environmental tax into (12), we can obtain the equilibrium number of private firms

---

[11] Due to the profit-maximization and zero-profit conditions, each firm's equilibrium output is the difference between average cost and marginal cost. Thus, each firm produces less than the social optimum where the average cost equals the marginal cost. This is the so-called business-stealing effect, which causes excessive entry into the market.

$$n^P = \frac{A-d}{2}\sqrt{\frac{6}{F}} - 3. \quad (16)$$

Note that we have $n^P > 0$ in the regions of $0 < F < \frac{(A-d)^2}{24}$.

This yields the optimal output levels of each private firm and market output:

$$q_i^P = \frac{\sqrt{6F}}{3},\ Q^P = A - d - \frac{2\sqrt{6F}}{3}. \quad (17)$$

Finally, the consumer surplus, environmental damage, and social welfare are

$$CS^P = \frac{1}{2}\left(A - d - \frac{2\sqrt{6F}}{3}\right)^2,\ ED^P = d(A - d - \frac{2\sqrt{6F}}{3}),\ W^P = \frac{1}{2}\left(A - d - \frac{2\sqrt{6F}}{3}\right)^2. \quad (18)$$

It is noteworthy that the social welfare is identical to the consumer surplus in (18) in a free entry private oligopoly, i.e., $CS^P = W^P$.

### 3.2. Mixed market

When the fixed cost is large ($F_0 \leq F < \frac{3(2-\alpha)^2(A-t)^2}{8(3-\alpha)^2}$), the CSR-frim exists in the long-run equilibrium. Using the results in (9), we have consumer surplus, environmental damage, and social welfare as follows:

$$CS = \frac{1}{2}\left(A - t - \frac{2\sqrt{6F}}{3}\right)^2,\ ED = d(A - t - \frac{2\sqrt{6F}}{3}),$$

$$W = \frac{4-2\alpha-\alpha^2}{3}F - \frac{(4A-A\alpha-A\alpha^2-4d+t\alpha+t\alpha^2)}{6}\sqrt{6F} + \frac{(A-t)(4A-A\alpha^2-8d+4t+t\alpha^2)}{8}. \quad (19)$$

In the first stage, the government chooses the environmental tax to maximize its social welfare in (19). The optimal environmental tax is

$$t^F = \frac{1}{(4+\alpha^2)}(A\alpha^2 + 4d - \frac{2\alpha(1+\alpha)\sqrt{6F}}{3}), \quad (20)$$

where superscript "F" denotes the equilibrium outcome of this free-entry mixed market. Then, from (20), we can derive that $t^F > d$ when[12] $0 < F < \frac{3(2-\alpha)^2(A-d)^2}{2(6-3\alpha+\alpha^2)^2}$. Then we obtain the following lemma.

**Lemma 2** *The optimal environmental tax is higher than marginal environmental damage in free entry private market where a CSR-firm exists.*

Lemma 2 represents that a higher environmental tax than marginal environmental damage can be used

[12] Note that $\frac{3(2-\alpha)^2(A-d)^2}{2(6-3\alpha+\alpha^2)^2} < \frac{3(2-\alpha)^2(A-t)^2}{8(3-\alpha)^2} = \frac{6(A-d)^2}{(4-\alpha)^2}$.

to control the number of private firms when the number is small (due to a higher fixed entry cost). This is in contrast to the result in Lemma 1 where a CSR-firm does not exist. The CSR-frim is aggressive in producing output, given the number of entering firms, which might increase total outputs and environmental damage as well. Thus, a higher taxation that decreases total market outputs is required in a mixed market under free entry equilibrium.

Substituting the optimal environmental tax into (8), we can obtain the optimal number of private firms:

$$n^F = \frac{(2-\alpha)(A-d)}{4+\alpha^2}\sqrt{\frac{6}{F}} - \frac{2(6-3\alpha+\alpha^2)}{4+\alpha^2}. \tag{21}$$

Then, we have the equilibrium outputs as follows:

$$q_0^F = \frac{2\left(3\alpha(A-d)-\sqrt{6F}(2-2\alpha+\alpha^2)\right)}{3(4+\alpha^2)},\ q_i^F = \frac{\sqrt{6F}}{3},\ Q^F = \frac{2(6A-6d-\sqrt{6F}(4-\alpha))}{3(4+\alpha^2)}. \tag{22}$$

Substituting also these outputs, we can obtain the profit of firm 0 as follows:

$$\pi_0^F = \frac{8\sqrt{6F}\alpha(A-d+A\alpha-d\alpha)}{3(4+\alpha^2)^2} - \frac{2(A-d)^2\alpha^2}{(4+\alpha^2)^2} - \frac{\alpha(32+8\alpha-\alpha^3)}{3(4+\alpha^2)^2}F. \tag{23}$$

Hence, the CSR-firm can earn a non-negative profit at free entry equilibrium only when $\frac{6\alpha^2(A-d)^2}{(8+4\alpha+\alpha^2)^2} \leq F < \frac{6(A-d)^2}{(4-\alpha)^2}$.

Finally, consumer surplus, environmental damage, and social welfare are as follows:

$$CS^F = \frac{2\left(6A-6d-\sqrt{6F}(4-\alpha)\right)^2}{9\left(4+\alpha^2\right)^2},\ ED^F = \frac{2d(6A-6d-\sqrt{6F}(4-\alpha))}{3(4+\alpha^2)},\ W^F = \frac{2}{4+\alpha^2}\left(A-d-\frac{4-\alpha}{6}\sqrt{6F}\right)^2. \tag{24}$$

The social welfare increases as the fixed cost becomes smaller, in which case more private firms enter the market and thus in return the optimal tax becomes higher.

## 4. Policy Discussions

### 4.1. The welfare effect of a CSR-firm

We compare the equilibrium outcomes between private and mixed markets when the CSR-firm exists in free entry markets where $\frac{6\alpha^2(A-d)^2}{(8+4\alpha+\alpha^2)^2} \leq F < \frac{6(A-d)^2}{(4-\alpha)^2}$. First, we have $n^P > n^F$ and $t^P < t^F$: a higher environmental tax in a mixed market yields a smaller number of private firms. It represents that the CSR-firm is beneficial to reduce the excessive entry problem. Second, we have $Q^P > Q^F$: total market outputs in a private oligopoly are greater than those in a mixed oligopoly. It implies that the CSR-firm is also beneficial to the environment, i.e., $ED^P > ED^F$. Third, we have $W^P > W^F$ if $F <$

$F_w \equiv \frac{3\left(8+8\alpha+5\alpha^2-4(1+\alpha)\sqrt{4+\alpha^2}\right)(A-d)^2}{2(8+3\alpha)^2}$ while $W^P < W^F$ if $F_w < F < \frac{3(2-\alpha)^2(A-d)^2}{2(6-3\alpha+\alpha^2)^2}$. It shows that a CSR-firm is beneficial to both social welfare and environmental quality when fixed cost is large, i.e., $F_w < F < \frac{3(2-\alpha)^2(A-d)^2}{2(6-3\alpha+\alpha^2)^2}$. Fig. 1 shows the welfare and profit of the CSR-firm in mixed and private markets.

< FIGURE 1. Welfare and profit comparisons under free entry >

**Proposition 1** *The environment is less damaged but social welfare deteriorates accompanied with a CSR-firm when the fixed cost is low.*

We can provide economic interpretation. A CSR-firm is aggressive and thus it produces outputs at a higher cost (also called the production cost-increasing effect), but as it produces more outputs than private firms, it can reduce the number of private firms (this is the cost-decreasing effect of the duplication of fixed costs). Therefore, the welfare consequences depends on how the two opposite effects work. In the case that the fixed cost is lower than a certain level and thus a large number of private firms enters the free entry mixed market, the CSR-firm's production cost-increasing effect is less significant than the cost-decreasing effect of the duplication of fixed costs. Therefore, when the fixed cost is large, the CSR-firm is beneficial to the society than a private oligopoly.

The proposition shows that the welfare effects of the CSR-firm depend on the degree of CSR and fixed cost. It also implies that an appropriate regulatory framework might be necessary for promoting an appropriate degree of CSR. Thus, the active role of governmental guideline for promoting CSR, rather than considering it on a voluntary basis, might be useful.[13]

### 4.2. Optimal promotion for CSR

We examine the optimal promotion of CSR from the viewpoint of welfare, rather than voluntarily given degree of CSR in the market selection. Then, the government determines not only the optimal environmental tax rate but the optimal degree of CSR. In the first stage, the government chooses the degree of CSR promotion and environmental tax to maximize its social welfare in (19). Then, the optimality condition of environmental tax in (20) yields the following optimal degrees of CSR promotion and environmental tax rate:

---

[13] The promotion of CSR has become a priority in the policy agenda for sustainable development in recent years. In particular, the encouragement of CSR became a central policy objective in the developed countries such as United States and European Union. See, Liu et al. (2018)

$$t^* = d \text{ and } \alpha^* = \frac{4\sqrt{F}}{\sqrt{6}(A-d)-4\sqrt{F}}. \tag{25}$$

where superscript "*" denotes the optimal solutions.

**<u>Lemma 3</u>** *The optimal environmental tax is exactly determined at the level of marginal environmental damage in free entry market when the optimal degree of CSR is promoted.*

A few remarks are in order. First, accompanied with the optimal promotion of CSR, the optimal environmental tax is the same with marginal environmental damage, i.e., $t^* = t^P = d < t^F$. Thus, the optimal promotion of CSR will reduce the optimal tax rate to the Pigouvian level, which will maximize the welfare than a higher taxation. Second, we have $\alpha^* \gtreqless 0$ if $F \lesseqgtr \frac{3(A-d)^2}{8}$ while $\alpha^* \gtreqless 1$ if $F \lesseqgtr \frac{3(A-d)^2}{32}$. Thus, the optimal promotion of CSR can be positive or negative and even it can be larger than full consideration of consumer surplus, depending on the entry cost. In particular, it should be negative if the entry cost is sufficiently large while it should be larger than one if the entry cost is sufficiently small. It implies that the excessive entry problem is serious, the role of CSR-firm should be highly emphasized. Finally, we have $\frac{\partial \alpha^*}{\partial A} < 0$, $\frac{\partial \alpha^*}{\partial d} > 0$ and $\frac{\partial \alpha^*}{\partial F} < 0$. This states that the optimal degree of CSR should be more promoted as (i) market size decreases, (ii) marginal environmental damage increases and (iii) entry cost decreases.

Substituting the optimal degrees of CSR promotion and environmental tax into (8), we can obtain the equilibrium number of private firms:

$$n^* = \frac{A-d}{2}\sqrt{\frac{6}{F}} - 4. \tag{26}$$

Note that the equilibrium number of private firms in (26) is smaller than that in the private market in (16), i.e., $n^*$ case. $n^P > n^*$. Thus, the optimal promotion of CSR is effective to reduce excessive entry problem.

Then, we have the equilibrium outputs as follows:

$$q_0^* = \frac{2\sqrt{6F}}{3},\ q_i^* = \frac{\sqrt{6F}}{3},\ Q^* = A - d - \frac{2\sqrt{6F}}{3}. \tag{27}$$

Note also that the market output is the same as that in the private market in (17). Thus, the optimal promotion of CSR provides the same level of consumer surplus.

Substituting also these outputs, we can obtain the profit of firm 0 as follows:

$$\pi_0^* = \frac{F}{3}. \tag{28}$$

Thus, the CSR-firm under the optimal promotion of CSR can earn a positive profit and survive in free entry market. In sum, the emergence of CSR-firm can be beneficial to the society when an appropriate regulatory framework for the promotion of CSR is constructed. Therefore, the active role of governmental guideline for promoting CSR, rather than considering it on a voluntary basis, is imperative.

Finally, we obtain the consumer surplus, environmental damage and social welfare under the optimal promotion of CSR:

$$CS = \frac{1}{2}\left(A - d - \frac{2\sqrt{6F}}{3}\right)^2,\ ED = d(A - d - \frac{2\sqrt{6F}}{3}),\ W = \frac{1}{2}\left(A - d - \frac{2\sqrt{6F}}{3}\right)^2 + \frac{F}{3}. \tag{29}$$

These results show that consumer surplus and environmental damage are the same with the results in private market, but the social welfare can be enhanced. Then we obtain the following proposition.

**Proposition 2** *The social welfare can be enhanced under the optimal promotion of CSR irrespective of the fixed cost.*

### 4.3. Comparisons with blockaded entry

We compare with the blockaded entry case where the government can control the number of entering private firms in a mixed market.[14] When a CSR-firm exists and the number of private firms is exogenously given, from (6) and (7), the social welfare becomes

$$W = \frac{(1+n)(A-t)\left(A(2-\alpha)(8+2n+n\alpha)+t\left(8+4n+n\alpha^2\right)-8d(3+n-\alpha)\right)}{8(3+n-\alpha)^2} - (n+1)F. \tag{30}$$

The differentiation of $W$ yields the following optimal environmental tax under blockaded entry:

$$t^B = d + \frac{(4\alpha-4+n\alpha^2)(A-d)}{8+n(4+\alpha^2)}, \tag{31}$$

where superscript "B" denotes the equilibrium outcome of the blockaded-entry mixed market. From (31), we have $t^B \lesseqgtr d$ when $\alpha \lesseqgtr \frac{2(\sqrt{1+n}-1)}{n}$. In special, $t^B < d$ when $\alpha = 0$ while $t^B > d$ when $\alpha = 1$. Then we obtain the following lemma.

**Lemma 4** *The optimal environmental tax is lower (higher) than marginal environmental damage when the degree of CSR is lower (higher) under blockaded entry.*

This result is comparable with the analysis of Lambertini and Tampiere (2015) and Leal *et al.* (2018)

[14] In reality, the government might not be able to control the number of private firms perfectly, on account of political and institutional interactions and/or the historical background of the regulated industry. For example, if private investors have already invested high fixed and sunk costs before an entry regulation is imposed, the government should consider the number of existing private firms as a fixed number. See Spiller (2013).

who considered Cournot duopoly and showed that CSR-firm produces larger output, which induces rivals to reduce their output. Thus, when the firm adopts CSR activities too high under blockaded entry, a higher taxation than the marginal environmental damage can be optimal to the society. This is in contrast to the results when the degree of CSR is higher in a private oligopoly under blocked entry, where the optimal environmental tax should be lower than the marginal environmental damage.[15] It implies that under-production of the private firms is outweighed by over-production by the consumer-friendly firm. Thus, a higher environmental tax will reduce production that is in excess of welfare maximization. In addition, the optimal tax increases as the number of private firms increases.

The equilibrium outputs of the firms under blockaded entry are as follows:

$$q_0^B = \frac{2(2+n\alpha)(A-d)}{8+n(4+\alpha^2)},\ q_i^B = \frac{2(2-\alpha)(A-d)}{8+n(4+\alpha^2)},\ Q^B = \frac{4(1+n)(A-d)}{8+n(4+\alpha^2)}. \tag{32}$$

Note again that the output of CSR-firm is larger than that of the private firm under blockaded entry, i.e., $q_0^B > q_i^B$. Substituting these outputs, we can obtain the profits of the firms:

$$\pi_0^B = \frac{2(2+n\alpha)(6-4\alpha-n\alpha)(A-d)^2}{(8+4n+\alpha^2 n)^2} - F,\ \pi_i^B = \frac{6(2-\alpha)^2(A-d)^2}{(8+4n+\alpha^2 n)^2} - F. \tag{33}$$

Note that CSR-firm can earn non-negative profits at the blockaded-entry equilibrium only when $0 < F < \frac{2(2+n\alpha)(6-4\alpha-n\alpha)(A-d)^2}{(8+4n+\alpha^2 n)^2}$ under the optimal tax rate in (31).

Finally, consumer surplus, environmental damage, and social welfare are follows:

$$CS^B = \frac{8(1+n)^2(A-d)^2}{(8+4n+\alpha^2 n)^2},\ ED^B = \frac{4d(1+n)(A-d)}{8+n(4+\alpha^2)},\ W^B = \frac{2(A-d)^2(1+n)}{8+n(4+\alpha^2)} - (n+1)F. \tag{34}$$

Suppose that $0 < F < \frac{6(A-d)^2(2-\alpha)^2}{(8+4n+\alpha^2 n)^2}$, where the private firm under both free entry and blockaded entry earns non-negative profit at equilibrium. Then, given $n = n^F$ in (21), where the numbers of firms in both blockaded entry and free entry are the same, comparison between blockaded entry and free entry provides the following proposition.

**<u>Proposition 3</u>** *The optimal tax under blockaded entry is lower than that under free entry when* $n = n^F$.

*Proof:* Substituting (21) into (26) , we have $t^B = \frac{\sqrt{6}(A-d)(4d+A\alpha^2)+2(A(4-2\alpha+3\alpha^2-\alpha^3)-2d\alpha(1+\alpha))}{(\sqrt{6}(A-d)-2\sqrt{F}(1-\alpha))(4+\alpha^2)}$ when $n = n^F$. And then comparing this value with (20) yields $t^F - t^B = \frac{4\sqrt{F}(1-\alpha)\left(6A-6d+\sqrt{6F}(\alpha+\alpha^2)\right)}{3\left(\sqrt{6}(A-d)-2\sqrt{F}(1-\alpha)\right)(4+\alpha^2)} > 0$

[15] It is well-known that the optimal tax on private oligopoly under blockaded entry should be less than the marginal social damage, depending upon the relative effects of distortions such as market power and externality. See, for example, Lee (1999) and Lee and Park (2011).

when $0 < F < \frac{3(2-\alpha)^2(A-d)^2}{2(6-3\alpha+\alpha^2)^2}$.

It states that a free-entry policy calls for a higher environmental tax even in the presence of CSR-firm because of the excessive entry problem, in which a higher taxation can reduce the number of firms but reduce the welfare, compared to the blockaded entry.

**<u>Proposition 4</u>** *Both the environmental damage and social welfare under blockaded entry are higher than those under free entry when* $n = n^F$.

*Proof:* Substituting (21) into (24) and (29), and then comparing the values yields (i) $ED^F - ED^B = -\frac{4d\sqrt{F}\left(6A-6d-\sqrt{6}\sqrt{F}(4-\alpha)\right)(1-\alpha)}{3\left(\sqrt{6}A-\sqrt{6}d-2\sqrt{F}(1-\alpha)\right)(4+\alpha^2)} < 0$, and (ii) $W^F - W^B = -\frac{4F\left(\sqrt{6}A-\sqrt{6}d-\sqrt{F}(4-\alpha)\right)(1-\alpha)^2}{3\left(\sqrt{6}A-\sqrt{6}d-2\sqrt{F}(1-\alpha)\right)(4+\alpha^2)} < 0$ when $0 < F < \frac{3(2-\alpha)^2(A-d)^2}{2(6-3\alpha+\alpha^2)^2}$.

Fig. 2 shows the simulation result of environmental damage and social welfare when $A = F = 100$ and $d = 10$ in both blockaded entry and free entry markets. It shows that the distorting effect under free entry can be reduced as the degree of CSR increases. It implies that the excessive entry problems call for a higher environmental taxation, but it depends on the degree of CSR. Therefore, the active role of governmental guideline for CSR, rather than considering it on a voluntary basis, is necessary.

< FIGURE 2. The effects of entry regulation>

### 4.4. Pollution abatement activities

It is reasonable to expect that free entry may lead to some improvement in eco-technology because pollution production might be abated—with related processes becoming "greener"—in the long run. We consider the case that polluting firms can choose pollution abatement technology and examine how pollution abatement activities affect our results in a mixed market. For the simplicity of comparison without loss of further insights, in this section we assume that the weight assigned to consumer equals to zero, i.e., $\alpha = 0$

Suppose that firm *j* chooses the pollution abatement level $a_j$. The emission level of each firm and market are given by $e_j = q_j - a_j$, and $E = e_0 + \sum_{i=1}^{n} e_i$, where firm *j* can reduce its emission $a_j$ by investing the amount $\frac{1}{2}a_j^2$ in pollution abatement activities.[16] In the second stage, the CSR-firm and

[16] For simplicity of tractability, in line with the literature (Wang and Wang 2009, Lee and Park 2011, Kim et al

private firm simultaneously choose their levels of output and pollution abatement to maximized their objective functions. The equilibrium output and pollution abatement levels of the CSR-firm and private firm are

$$q_0 = \frac{A-t}{2},\ q_i = \frac{A-t}{2(2+n)},\ a_0 = a_i = t. \tag{35}$$

Note that environmental tax will not only reduce the output level but also the emission level, by inducing higher abatement activities. Thus, direct taxation effect has both the output-decreasing effect and the emission-decreasing effect.

Then, the profits of the firms are as follows:

$$\pi_0 = \frac{(A-t)^2(2-n)}{8(2+n)} + \frac{t^2}{2} - F,\ \pi_i = \frac{3(A-t)^2}{8(2+n)^2} + \frac{t^2}{2} - F. \tag{36}$$

Using the zero-profit conditions of the private firms under free entry, we can obtain the equilibrium number of private firms under free-entry conditions:

$$n = \frac{A-t}{2}\sqrt{\frac{3}{2F-t^2}} - 2. \tag{37}$$

For a positive number of private firms, we assume that $0 < F < \frac{3A^2-6At+19t^2}{32}$. Note that the environmental tax will decrease (increase) the number of firms under free entry when the tax is low (high), that is, $\frac{\partial n}{\partial t} < 0$ if $t < \frac{2F}{A}$ while $\frac{\partial n}{\partial t} > 0$ if $t > \frac{2F}{A}$. This is in sharp contrast to the case without abatement activities. This is because the private firm has the option to reduce its emission level without lowering its output. Therefore, depending on the fixed cost, the indirect taxation effects to reduce the outputs of private firms will cancel out or exaggerate the direct taxation effects.

Substituting the number of private firms, we can obtain the equilibrium output and emission levels of the firms and the market:

$$q_0 = \frac{A-t}{2},\ q_i = \sqrt{\frac{2F-t^2}{3}},\ Q = A - t - 2\sqrt{\frac{2F-t^2}{3}},$$

$$e_0 = \frac{A-3t}{2},\ e_i = \sqrt{\frac{2F-t^2}{3}} - t,\ E = A - \frac{3At-7t^2+8F}{6}\sqrt{\frac{3}{2F-t^2}}. \tag{38}$$

We can confirm that direct taxation effects will reduce the outputs of the firms, but their effects on the outputs of the firms differ depending on the fixed cost and tax levels. However, owing to the indirect taxation effects on the number of firms, a low (high) environmental tax will decrease (increase) the

---

2018), we focus on end-of-pipe abatement, which is additively separable. According to all empirical reports, end-of-pipe abatement goods and services account for more than 70% of the pollution treatment sector. See David *et al*. (2011).

market outputs, i.e., $\frac{\partial Q}{\partial t} < 0$ when $t < \sqrt{\frac{6F}{7}}$, and $\frac{\partial Q}{\partial t} > 0$ when $t > \sqrt{\frac{6F}{7}}$. On the other hand, because of the direct taxation effects on the abatement activities, the environmental damage will decrease, i.e., $\frac{\partial E}{\partial t} < 0$.

The resulting CSR-firm's profit, consumer surplus, environmental damage, and social welfare are as follows

$$\pi_0 = (A-t)\sqrt{\frac{2F-t^2}{3}} - \frac{(A+t)(A-3t)}{8} - F,$$

$$CS = \frac{1}{2}(A - t - 2\sqrt{\frac{2F-t^2}{3}})^2,\ ED = d(A - \frac{3At-7t^2+8F}{6}\sqrt{\frac{3}{2F-t^2}}),$$

$$W = \frac{F}{3} + \frac{9A^2-24Ad+6At+5t^2}{24} - 4(4AF - 8dF - 3Adt + 4Ft + At^2 + 7dt^2 - 5t^3)\sqrt{\frac{3}{2F-t^2}}. \quad (39)$$

Finally, if we evaluate the tax at the marginal environmental damage, the differentiation of $W$ with respect to $t$ yields the following:

$$\left.\frac{\partial W}{\partial t}\right|_{t=d} = \frac{3A+5d}{12} - \frac{Ad-3d^2+4F}{6}\sqrt{\frac{3}{2F-d^2}}, \quad (40)$$

where (40) $\gtrless 0$ when $\sqrt{2F-d^2} \gtrless \frac{2\sqrt{3}(Ad-3d^2+4F)}{3A+5d}$. It shows that the optimal tax should be lower or higher than the marginal environmental damage, depending on the sizes of $F$ and $d$. Again, this contrasts sharply with the case without abatement activities. This is because the indirect taxation effects to reduce the outputs of private firms can exaggerate the direct taxation effects, and thus, the market outputs will be reduced when the environmental tax is low. This emphasizes the importance of abatement technology in determining the optimal environmental tax under free entry equilibrium.

When we evaluate the welfare with abatement activities in (39) at the optimal tax level without abatement activities in (20), we have that $\left.\frac{\partial W}{\partial t}\right|_{t=t^*} < 0$. It implies that the optimal tax with abatement activities should be lower than that without abatement technology. Thus, the abatement activities will reduce the optimal environmental tax under the free entry market. But, the number of private firms depends on the sizes of $F$ and $d$. That is, $\frac{\partial n}{\partial t} < 0$ if $t < \frac{2F}{A}$ and $\frac{\partial n}{\partial t} > 0$ if $t > \frac{2F}{A}$.

**Proposition 5** *Pollution abatement activities might reduce the optimal tax while increase the number of private firms when the tax is lower.*

*Proof:* Because of its analytic complexity, we employ a simple simulation and examine the comparative effects of abatement activities on the optimal tax and social welfare. Fig. 3 shows the simulation result when $A = 100$ and $d = 10$, where superscript "A" denotes the equilibrium outcome when the polluting firms can choose pollution abatement technology.

< FIGURE 3. The effects of abatement activities >

From Fig. 3, we can have $t^A < t^F$, $n^A > n^F$, $ED^F > ED^A$ and $W^A > W^F$. Thus, the eco-technology will reduce the optimal tax and increase the number of private firms. This will lead to an increase in the market output, while the total emission level decreases substantially on account of the existence of pollution abatement activities. Further, the abatement activities will increase not only consumer surplus but also social welfare. Thus, providing an efficient abatement technology in a free entry market is important to improve not only environment but also social welfare in the long run.

**5. Conclusions**

We have considered a consumer-friendly firm with CSR-initiatives in Cournot markets with endogenous entry and examined the effects of CSR on environmental tax and welfare consequences. We showed that the optimal tax under free entry is higher than that under blockaded entry and also higher than marginal environmental damage. However, we showed that a higher taxation is socially excessive from the viewpoint of socially optimal degree of CSR. Thus, the active role of governmental guideline for promoting CSR, rather than considering it on a voluntary basis, is necessary. This also implies that an appropriate regulatory framework for CSR promotion should be constructed. We further showed that the environment is less damaged but social welfare deteriorates accompanied with a CSR-firm when the fixed cost is low. However, we also showed that pollution abatement activities will reduce the optimal tax in free entry markets, but improves both environmental quality and social welfare.

Our analysis should be extended to incorporate the general formulations of demand and cost functions.[17] For example, it will be interesting to investigate the case that the consumer-friendly firm considers environmental damages in its objective function.[18] Finally, we examined quantity competition, but price competition can be an alternative in oligopolistic competition. These challenging issues are promising future research.

[17] Lee (1999) shows that the optimal tax in a free-entry private market depends on the curvature of the market demand function, while Amir and Lambson (2000) point out the importance of the cost function in determining the output of an oligopoly. In a free-entry mixed market, Cato (2008) also shows that the optimality of privatization depends on the abatement cost function.

[18] See, for example, Kamijo and Tomaru (2014), Liu et al. (2015) and Lee and Xu (2018).

## References

Amir, R. and V. E. Lambson (2000), "On the Effects of Entry in Cournot Markets," *Review of Economic Studies* 67(2), pp.235-254.

Bárcena-Ruiz, J.C. and M.B. Garzón (2006), "Mixed Oligopoly and Environmental Policy," *Spanish Economic Review* 8(2), pp.139-160.

Beladi, H. and C.C. Chao (2006), "Does Privatization Improve the Environment?" *Economics Letters* 93(3), pp. 343-347.

Brand, B., Grothe, M. (2013), "A Note on 'Corporate Social Responsibility and Marketing Channel Coordination," *Research in Economics* 67, pp.324–327.

Brand, B., Grothe, M. (2015), "Social Responsibility in a Bilateral Monopoly," *Journal of Economics* 115, pp.275–289.

Brandao, A. and S. Castro (2007), "State-Owned Enterprises as Indirect Instruments of Entry Regulation," *Journal of Economics* 92(3), pp. 263-274.

Cato, S. (2008), "Privatization and the environment," *Economics Bulletin* 12(19), pp. 1-10.

Cato, S. and T. Matsumura (2012), "Long-Run Effects of Foreign Penetration on Privatization Policies," *Journal of Institutional and Theoretical Economics* 168(3), pp. 444-454.

Cato, S. and T. Matsumura (2015), "Optimal Privatisation and Trade Policies with Endogenous Market Structure," *Economic Record* 91(294), pp. 309-323.

Chang, Y.M., H.Y. Chen, L.F.S. Wang, and S.J. Wu (2014), "Corporate Social Responsibility and International Competition: A Welfare Analysis," *Review of International Economics* 22(3), pp. 625-638.

David, M., Nimubona, A.-D. and B. Sinclair-Desgane (2011), "Emission Taxes and the Market for Abatement Goods and Services," *Resource and Energy Economics* 33(1), pp. 179-191.

De Fraja, G. and F. Delbono (1989), "Alternative Strategies of a Public Enterprise in Oligopoly," *Oxford Economic Papers* 41(2), pp. 302–311.

Etro, F. (2008), "Stackelberg Competition with Endogenous Entry," *Economic Journal* 118, pp. 1670-1697.

Fujiwara, K. (2009), "Environmental Policies in a Differentiated Oligopoly Revisited," *Resource and Energy Economics* 31(3), pp. 239-247.

Goering,G.E.(2012), "Corporate Social Responsibility and Marketing Channel Coordination," *Research in Economics* 66(2), pp. 142-148.

Goering, G. E. (2014), "The Profit-Maximizing Case for Corporate Social Responsibility in a Bilateral Monopoly," *Managerial and Decision Economics* 35(7), pp. 493-499.

Hsu, C.C., J.Y. Lee and L.F.S. Wang (2017), "Consumers Awareness and Environmental Policy in

Differentiated Mixed Oligopoly," *International Review of Economics and Finance* 51, pp. 444-454.

Ino, H. and T. Matsumura (2010), "What Role Should Public Enterprises Play in Free-Entry Markets?" *Journal of Economics* 101(3), pp. 213–230.

Ino, H. and T. Matsumura (2012), "How Many Firms Should Be Leaders? Beneficial Concentration Revisited," *International Economic Review* 53(4), pp. 1323-1340.

Kamijo, Y. and Y. Tomaru (2014), "The Endogenous Objective Function of a Partially Privatized Firm: A Nash Bargaining Approach," *Economic Modelling* 39, pp. 101-109.

Katsoulacos, Y. and A. Xepapadeas (1995), "Environmental Policy under Oligopoly with Endogenous Market Structure," *Scandinavian Journal of Economics* 97(3), pp. 411-420.

Kopel, M. and B. Brand (2012), "Socially Responsible Firms and Endogenous Choice of Strategic Incentives," *Economic Modelling* 29(3), pp. 982-989.

KPMG, T. (2013), "KPMG International Survey of Corporate Responsibility Reporting," *Amsterdam, The Netherlands: KPMG*.

Lambertini, L. and Tampieri, A. (2015), "Incentives, Performance and Desirability of Socially Responsible Firms in a Cournot Oligopoly," *Economic Modelling* 50, pp. 40 – 48.

Leal, M., Garcia, A. and Lee, S.H. (2018), "The Timing of Environmental Tax Policy with a Consumer-friendly Firm," *Hitotsubashi Journal of Economics* 59(1), pp. 25-43.

Lee, S.H. (1999), "Optimal Taxation for Polluting Oligopolists with Endogenous Market Structure," *Journal of Regulatory Economics* 15(3), pp. 293-308.

Lee, S.H. and C.H. Park (2011), "Environmental Regulations on Vertical Oligopolies with Eco-Industry," *Korean Economic Review* 27(2), pp. 311-327.

Lee, S.H. and Xu, L. (2018), "Endogenous Timing in Private and Mixed Duopolies with Emission Taxes," *Journal of Economics* 124(2), forthcoming.

Liu, C.C., Wang, L. and Lee, S.H. (2015), "Strategic Environmental Corporate Social Responsibility in a Differentiated Duopoly Market," *Economics Letters* 129, pp. 108–111.

Liu, Q., Wang, L. and Chen, C.L. (2018), "CSR in an Oligopoly with Foreign Competition: Policy and Welfare implications," *Economics Modelling*, forthcoming.

Mankiw, N.G. and M.D. Whinston (1986), "Free Entry and Social Inefficiency," *RAND Journal of Economics* 17(1), pp. 48-58.

Matsumura, T. and O. Kanda (2005), "Mixed Oligopoly at Free Entry Markets," *Journal of Economics* 84(1), pp. 27-48.

Matsumura, T. and A. Ogawa (2014), "Corporate Social Responsibility or Payoff Asymmetry? A Study of an Endogenous Timing Game," *Southern Economic Journal* 81(2), pp. 457–473.

Pal, R. and B. Saha (2015), "Pollution Tax, Partial Privatization and Environment," *Resource and Energy Economics* 40, pp. 19-35.

Requate, T. (2007), “Environmental Policy under Imperfect Competition,” In *The International Yearbook of Environmental and Resource Economics*, pp. 120-207.

Porter, M. E. and M. R. Kramer (2006), “Strategy and Society: the Link Between Corporate Social Responsibility and Competitive Advantage,” *Harvard Business Review* 84(12), pp. 78-92.

Spiller, P. (2013), “Transaction Cost Regulation,” *Journal of Economic Behavior and Organization* 89, pp. 232-242.

Steurer, R. (2010), “The Role of Governments in Corporate Social Responsibility: Characterising Public Policies on CSR in Europe,” *Political Science* 43, pp. 49–72.

Sugeta, H. (2017), “Environmental Policy and the Excess Entry Theorem,” In *Applied Approaches to Societal Institutions and Economics Springer Singapore*, pp. 227-241.

Suzumura, K. (2012), “Excess Entry Theorem after 25 years,” *Japanese Economic Review* 63(2), pp. 152-170.

Suzumura, K. and K. Kiyono (1987), “Entry Barriers and Economic Welfare,” *Review of Economic Studies* 54(1), pp. 157-167.

Wang, L.F.S. (2016), “Do Industrial and Trade Policy Lead to Excess Entry and Social Inefficiency?” *International Review of Economics and Finance* 43, pp. 354-362.

Wang, L.F.S., J.Y. Lee and C.C. Hsu (2014), “Privatization, Foreign Competition, and Social Efficiency of Free Entry,” *International Review of Economics and Finance* 31, pp. 138-147.

Wang, L.F.S., Y.C. Wang, and L. Zhao (2012), “Tariff Policy and Welfare in an International Duopoly with Consumer-Friendly Initiative,” *Bulletin of Economic Research* 64(1), pp. 56-64.

Wang, L.F.S. and J. Wang (2009), “Environmental Taxes in a Differentiated Mixed Duopoly,” *Economic Systems* 33(4), pp. 389-396.

Xu, L., S. Cho and S.H. Lee (2016), “Emission Tax and Optimal Privatization in Cournot–Bertrand Comparison,” *Economic Modelling* 55, pp. 73-82.

Xu, L. and S.H. Lee (2018), “Environmental Policies with Excess Burden of Taxation in Free-entry Mixed Markets,” *International Review of Economics and Finance,* forthcoming.

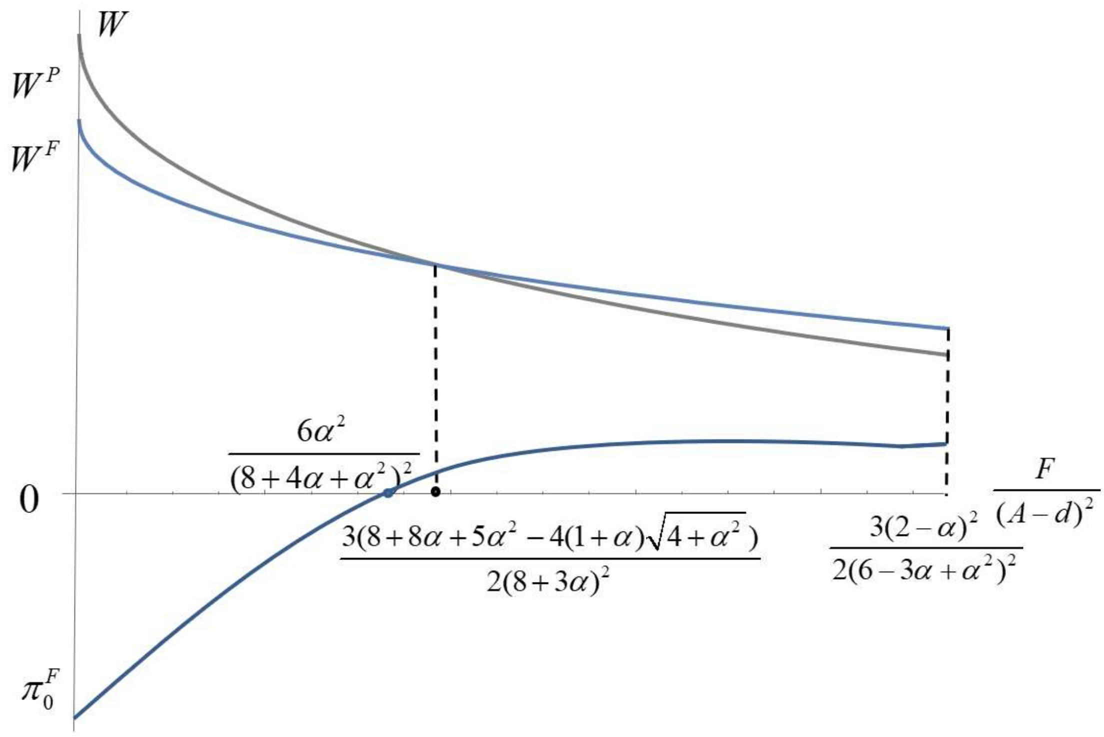


FIGURE 1. Welfare and profit comparisons under free entry

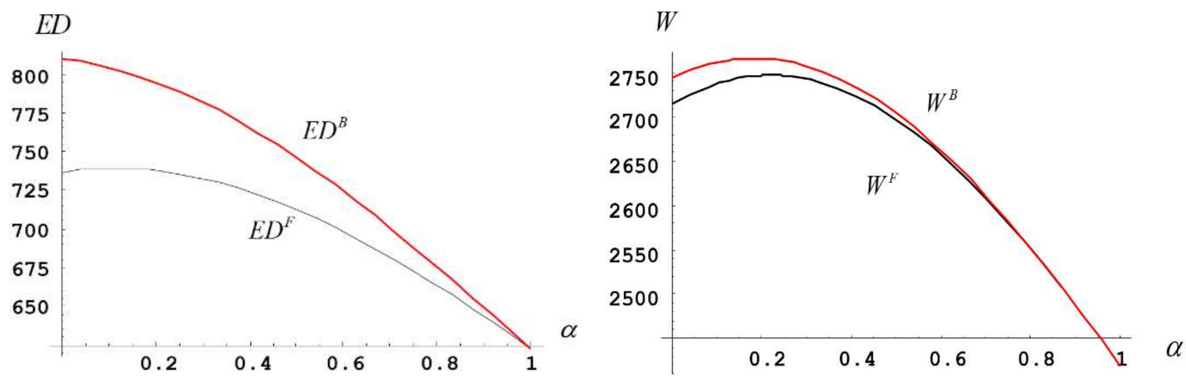


FIGURE 2. The effects of entry regulation

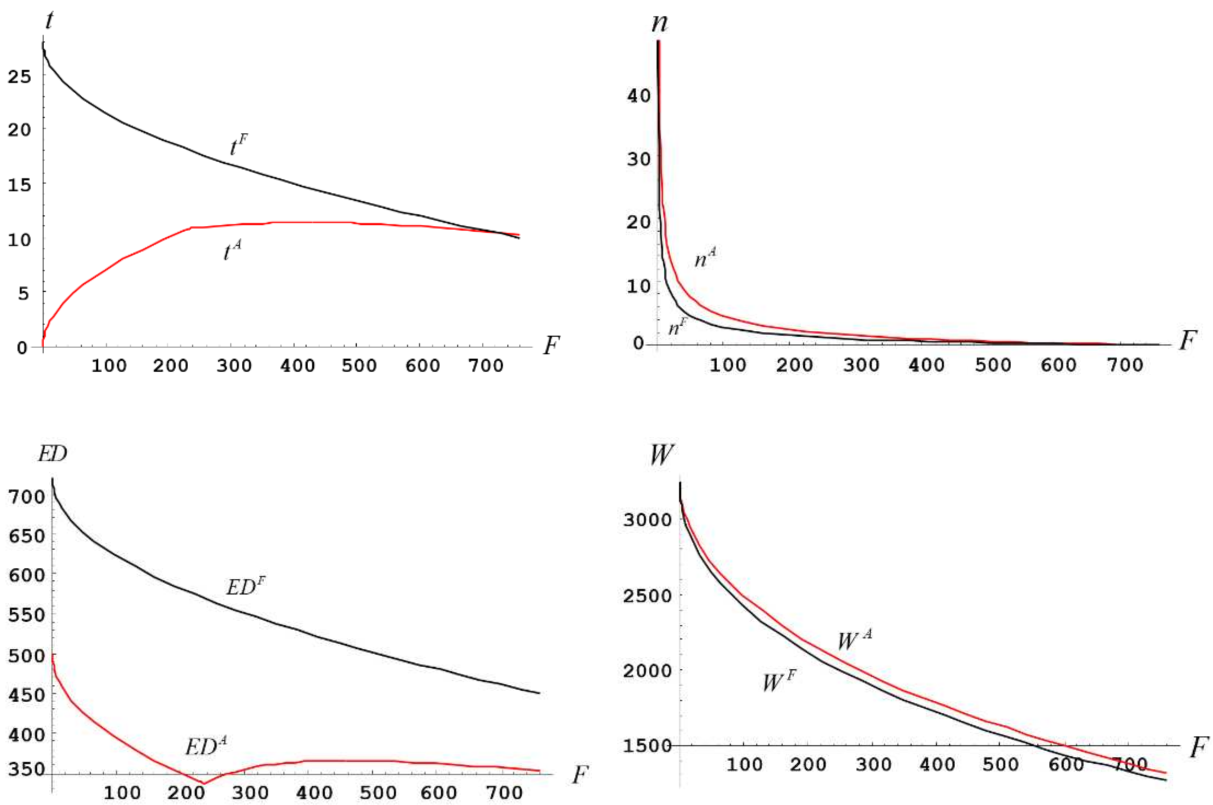


FIGURE 3. The effects of abatement activities