Corporate social responsibility and strategic trade policy: an endogenous timing game and its policy implications

Cho, Sumi and Lee, Sang-Ho and Hoang, Xoan

Chonnam National University, Chonnam National University, Chonnam National University

1 August 2019

Corporate social responsibility and strategic trade policy: an endogenous timing game and its policy implications

This study incorporates the corporate social responsibility (CSR) initiatives of a domestic firm and analyzes strategic trade policy toward a foreign firm in a different market structure. We show that the tariff rate under a foreign (domestic) firm's leadership is lowest when the degree of CSR is large (small). We also show that the foreign firm's leadership yields the highest welfare when the degree of CSR is intermediate, while the domestic firm's leadership yields the highest welfare otherwise. In an endogenous-timing game, we show that a simultaneous-move outcome is the unique equilibrium when the degree of CSR is small; thus, it is never socially desirable. We also show that the domestic firm's leadership can be an equilibrium, which results in the highest welfare when the degree of CSR is large. Finally, when the degree of CSR is large, collusive behaviors between the domestic and foreign firms can increase welfare.

Keywords: corporate social responsibility; strategic trade policy; endogenous-timing game; simultaneous-move; sequential-move
JEL codes: L13; L31; H21

1. INTRODUCTION

Corporate social responsibility (CSR) is defined as the responsibility of an organization for the impacts of its decisions on society and the community above and beyond its legal obligations, which is required for profit maximization through transparent and ethical behavior.[1] CSR activities have now become a mainstream global business strategy for a large number of firms.[2] For example, "GE's Ecomagination," "Nestle's Creating Shared Values," and "Unilever's Simple Living Plan" are some excellent examples of CSR statements. Nowadays, an increasing number of large firms are gradually adopting corporate self-disciplines that take more society-oriented concerns into account, rather than profits; that is, they regard ethical issues and community welfare as important business routines.

As CSR initiatives become more popular and are paid more attention in business economics, contrary to the traditional view of profit maximization as the sole objective of a private firm, it has also motivated recent analysis of applied economic theory, in which profit-oriented private firms compete with not-for-

[1] Also see the statements issued by the UK government: http://www.csr.gov.uk/policy.shtml
[2] According to KPMG (2015), nearly 92% of 250 of the largest companies worldwide issued CSR reports, and more than 30% of the companies in the United States adopted CSR in 2013, in comparison to 71% and 90% in the United Kingdom and Japan, respectively.

profit firms. In particular, there is a significant amount of recent research that regards firms employing CSR practices as consumer-friendly and concerned about consumer surplus.[3]

On the other hand, as the world's economy is moving towards higher levels of globalization and economic liberalization, the interaction between imports tariffs and CSR has also become an important policy agenda to ensure sustainable international trade agreements and domestic welfare. For example, the European Commission promotes CSR in the EU and encourages firms to adhere to international guidelines and principles.[4] Although several studies have demonstrated that consumer-oriented CSR initiatives significantly affect (Wang *et al.*, 2012; Chang *et al.*, 2014; Chao *et al.*, 2016; Manasakis *et al.*, 2018; Liu *et al.*, 2018; Xu and Lee, 2019), the role of CSR initiatives in market competition has not been well investigated. Hence, feedback on international CSR with different market leadership warrants greater attention.

In this study, we emphasize the role of a CSR firm in international trade and investigate the impact of CSR on strategic trade policy. In particular, we consider a duopoly market in which a domestic firm engages in CSR and competes with a foreign firm under the government's tariff policy. We analyze the equilibrium outcomes of different market structures, such as Cournot or Stackelberg competition, and examine the welfare consequences. We also extend the analysis into an endogenous-timing game, in which we ask when the firms are likely to play either a simultaneous-move Cournot game or a sequential-move Stackelberg game[5] and compare the equilibrium outcomes. Specifically, we compare two sequential-move games where either a domestic firm or a foreign firm leads the market.

Our analysis reveals that CSR initiatives play a critical role in choosing equilibrium outcomes and strategic trade policy. The following are our main findings. First, tariff rate under a sequential-move game with a domestic firm's leadership is lowest when the degree of CSR is small, while that under a sequential-move game with a foreign firm's leadership is lowest when the degree of CSR is large. Second, a domestic firm's leadership yields the highest welfare when the degree of CSR is either small or sufficiently large, while a foreign firm's leadership yields the highest welfare when the degree of CSR is intermediate. This implies that CSR initiatives can work for improving welfare by reducing the tariff. Third, a foreign firm's leadership always yields lower profit to a domestic firm under the simultaneous-move game, but a domestic firm's leadership yields higher profit under the simultaneous-

[3] Recently, Chang *et al.* (2014), Liu *et al.* (2018), and Xu and Lee (2018, 2019) explored tariff policy, while Liu *et al.* (2015), Hirose *et al.* (2017), Leal *et al.* (2018), and Garcia *et al.* (2018) examined environmental policy.

[4] The ISO 26000 guidance on social responsibility was published in 2010, and the updated OECD guidelines for multinational enterprises and the UN guiding principles on business and human rights were released in 2011. Further, the Global Reporting Initiative (GNI) provides a globally applicable framework for drawing up sustainability reports in accordance with internationally recognized criteria (see Aaronson, 2007; Vidal-Leon, 2013).

[5] The observable delay game has been intensively used in many contexts of game theory and economic theory. Recent developments are discussed in Lee and Xu (2018) and Garcia *et al.* (2019).

move game when the degree of CSR is large. Thus, from the viewpoint of profitability, a domestic firm has a strategic incentive to adopt a higher degree of CSR.[6]

Further, we examine an endogenous-timing game in the context of Hamilton and Slutsky (1990) and show that one simultaneous-move outcome is the unique equilibrium when the degree of CSR is small, while two sequential-move outcomes are the equilibrium otherwise. This indicates that when the degree of CSR is large, the simultaneous-move outcome disappears as the equilibrium of an endogenous-timing game and, thus, analysis of CSR initiatives using the Cournot model may become problematic. Further, it shows that when the degree of CSR is small, the simultaneous-move outcome as the equilibrium of an endogenous-timing game does not support the socially optimal outcome. However, the equilibrium under a domestic firm's leadership can result in the largest welfare when the degree of CSR is large. This also implies that the profit incentive for the domestic firm and the welfare incentive for the government can coincide in an endogenous-timing game with a larger CSR. Therefore, not only is voluntary adoption of CSR by the domestic firm imperative to improving welfare, but so too is the active role played by governmental tariff. This also implies that the policy agenda should be used to encourage and incentivize adoption of CSR through appropriate regulation and fiscal incentives.[7]

Finally, when the degree of CSR is large, we show that collusive behaviors between domestic and foreign firms also increase welfare.[8] This is an interesting result, as collusion between firms usually harms society. This result also coincides with the recent literature in Mukherjee and Sinha (2019), who consider the consumer-surplus-enhancing collusion and show that the firms' export cartel might improve the social welfare. However, this research examined profit-maximizing cooperation without considering CSR. Our analysis reveals that voluntary cooperation under higher CSR by the domestic firm might not necessarily be harmful to society.

This paper is organized as follows. Section 2 presents the basic model of a domestic CSR firm. In Section 3, we analyze market equilibrium in a fixed-timing game and compare the equilibrium outcomes and welfare. In Section 4, we examine an endogenous-timing game and provide policy implications. Section 5 concludes the paper.

[6] It is also well-documented in recent literature that strategic CSR initiatives can increase a firm's profitability (see, e.g., Lambertini and Tampieri, 2015; Liu *et al.*, 2015; Hirose *et al.*, 2017; Leal *et al.*, 2018; Xu and Lee, 2018; Lee and Park, 2019; Garcia *et al.*, 2019).

[7] The promotion of CSR has become a top priority in policy agenda in many developed countries such as the United States and in the European Union. This calls for an examination into what the government, businesses, and others should and could do to realize the full benefits of CSR. For more detail, see Liu *et al.* (2018) and Xu and Lee (2019).

[8] In Appendix C, we consider the case where a foreign firm adopts CSR and show that while most of the findings from the domestic firm's CSR case hold, collusive behaviors between the firms decrease social welfare.

2. MODEL

We consider a duopoly model where a domestic firm (firm D) and a foreign firm (firm F) compete in a domestic market with homogeneous products. We assume a linear inverse demand function, $P = 1 - Q$ where $Q = \sum_i q_i$ is total market outputs and q_i is the outputs of firm $i = D, F$. The consumer surplus is measured as $CS = \frac{1}{2}Q^2$. We also assume that both firms have the same quadratic cost functions, $C(q_i) = \phi + \frac{q_i^2}{2}$, where ϕ is fixed cost normalized to be zero without loss of generality.

The domestic firm adopts CSR, which takes care of the consumer surplus; in particular, the domestic firm is assumed to maximize the sum of its profit and a part of the consumer surplus as follows:

$$V_D = \pi_D + \alpha\, CS \tag{1}$$

where $\alpha \in [0,1]$ denotes the weight assigned to the consumer surplus and the profit of the domestic firm is defined as

$$\pi_D = (1 - q_D - q_F)q_D - \frac{{q_D}^2}{2} \tag{2}$$

The government can impose a tariff on the outputs of foreign firms to protect its domestic market. We assume that the foreign firm maximizes its profit only, in the form of:

$$\pi_F = (1 - q_D - q_F)\, q_F - \frac{{q_F}^2}{2} - t q_F \tag{3}$$

where t denotes the tax rate imposed by the government.

Then, social welfare is the sum of consumer surplus, tax revenue, and profit of the domestic firm, and is given by

$$SW = CS + \pi_D + T \quad \text{where} \quad T = t\, q_F \tag{4}$$

The game runs as follows: In the first stage, each firm simultaneously chooses whether to move early or late. In the second stage, the government chooses its optimal tariff for each game. In the final stage, the game played is simultaneous if both firms choose the same period, and sequential otherwise. For the purpose of comparison, we first examine the fixed-timing game in Section 3, which consists of the second and third stages. In Section 4, we advance to the endogenous-timing game, which incorporates the first stage and the following fixed-timing game. We will apply backward induction to obtain the subgame perfect equilibrium.

3. FIXED-TIMING GAME

(a) Simultaneous-move game: Cournot model

In choosing outputs in the final stage, each firm chooses its output simultaneously and independently. From the first-order conditions for maximizing the objective function of each firm, we obtain the following equilibrium output levels:

$$q_D^C = \frac{2+t+\alpha-t\alpha}{8-2\alpha}, \mathrm{q}_F^C = \frac{2-3t-\alpha+t\alpha}{8-2\alpha} \tag{5}$$

where the superscript C represents the Cournot game.

Substituting the equilibrium outputs yields the following results:

$$\begin{gathered}\pi_D^C = \frac{(2+t(1-\alpha)-\alpha)(6-5\alpha+t(3+\alpha))}{8(4-\alpha)^2}, \pi_F^C = \frac{3(2-t(3-\alpha)-\alpha)^2}{8(4-\alpha)^2} \\ V_D^C = \frac{3(2+t)^2+2(6-(11-t)t)\alpha-(5-t)(1-t)\alpha^2}{8(4-\alpha)^2}, \mathrm{CS}^C = \frac{(2-t)^2}{2(4-\alpha)^2} \\ \mathrm{SW}^C = \frac{28+28t-41t^2-2(2+t(15-13t))\alpha-5(1-t)^2\alpha^2}{8(4-\alpha)^2}\end{gathered} \tag{6}$$

In the second stage, using the welfare function in (6), the government decides its optimal tariff under the Cournot game. The optimal tariff in a simultaneous-move game is as follows:

$$t^C = \frac{14-5(3-\alpha)\alpha}{41-\alpha(26-5\alpha)} \tag{7}$$

Note that t^C is decreasing in α. Thus, strategic tariff policy is substitutable with the domestic firm's CSR activities.

Finally, we obtain the following equilibrium outcomes:

$$\begin{gathered}q_D^C = \frac{2(6-\alpha)}{41-\alpha(26-5\alpha)}, q_F^C = \frac{5-3\alpha}{41-\alpha(26-5\alpha)}, \pi_D^C = \frac{2(6-\alpha)(18-5(4-\alpha)\alpha)}{(41-\alpha(26-5\alpha))^2}, \pi_F^C = \frac{3(5-3\alpha)^2}{2(41-\alpha(26-5\alpha))^2} \\ V_D^C = \frac{432-\alpha(263-5\alpha(6+\alpha))}{2(41-\alpha(26-5\alpha))^2}, \mathrm{CS}^C = \frac{(17-5\alpha)^2}{2(41-\alpha(26-5\alpha))^2}, \mathrm{SW}^C = \frac{21-10\alpha}{82-2\alpha(26-5\alpha)}\end{gathered} \tag{8}$$

Note that the output of the domestic firm and consumer surplus increases as α increases while the output of the foreign firm increases when $\alpha < \frac{1}{15}(25 - 2\sqrt{130}) \approx 0.146$ and decreases in the other interval.

(b) Sequential-move game with domestic leadership: Stackelberg model

In this Stackelberg game, the domestic firm moves first and then the foreign firm chooses its quantity sequentially in the final stage. Then, the first-order condition of the foreign firm to maximize its own profit in (3) provides the reaction function of the foreign firm. By substituting this reaction function to

the objective function of the domestic firm in (1) and solving the first-order conditions, we obtain the following equilibrium output levels:

$$q_D^{SD} = \frac{6+3t+2\alpha-2t\alpha}{21-4\alpha},\ q_F^{SD} = \frac{5-8t-2\alpha+2t\alpha}{21-4\alpha} \tag{9}$$

where the superscript SD represents Stackelberg game with Domestic firm's leadership.

Substituting the equilibrium outputs yields the following results:

$$\begin{gathered}\pi_D^{SD} = \frac{(7(2+t)-2(5-t)\alpha)(3(2+t)+2(1-t)\alpha)}{2(21-4\alpha)^2},\ \pi_F^{SD} = \frac{3(5-2t(4-\alpha)-2\alpha)^2}{2(21-4\alpha)^2} \\ CS^{SD} = \frac{(11-5t)^2}{2(21-4\alpha)^2},\ V_D^{SD} = \frac{(2+t)^2+(5-t)(1-t)\alpha}{42-8\alpha} \\ SW^{SD} = \frac{205+184t-290t^2-4(8+t(39-35t))\alpha-20(1-t)^2\alpha^2}{2(21-4\alpha)^2}\end{gathered} \tag{10}$$

In the second stage, using the welfare function in (10), the government decides its optimal tariff under the Stackelberg game with the domestic firm's leadership as follows:

$$t^{\mathrm{SD}} = \frac{46-\alpha(39-10\alpha)}{5(29-2(7-\alpha)\alpha)} \tag{11}$$

Note also that t^{SD} is decreasing in α. Thus, the strategic tariff policy is substitutable with the domestic firm's CSR activities.

Finally, we obtain the following results:

$$\begin{gathered}q_D^{\mathrm{SD}} = \frac{48-7\alpha}{5(29-2(7-\alpha)\alpha)},\ q_D^{\mathrm{SD}} = \frac{48-7\alpha}{5(29-2(7-\alpha)\alpha)}, \\ \pi_D^{\mathrm{SD}} = \frac{(48-7\alpha)(112-\alpha(103-20\alpha))}{50(29-2(7-\alpha)\alpha)^2},\ \pi_F^{\mathrm{SD}} = \frac{3(17-8\alpha)^2}{50(29-2(7-\alpha)\alpha)^2} \\ \mathrm{CS}^{\mathrm{SD}} = \frac{(13-3\alpha)^2}{2(29-2(7-\alpha)\alpha)^2},\ V_D^{\mathrm{SD}} = \frac{5376-\alpha(1503+\alpha(269-85\alpha))}{50(29-2(7-\alpha)\alpha)^2},\ SW^{SD} = \frac{77-30\alpha}{10(29-2(7-\alpha)\alpha)}\end{gathered} \tag{12}$$

Note that the output of the domestic firm and consumer surplus increases as α increases while the output of foreign firm increases when $\alpha < \frac{1}{8}\left(17-\sqrt{265}\right) \approx 0.090$ and decreases in the other interval

(c) Sequential-move game with foreign leadership: Stackelberg model

In this Stackelberg game, the foreign firm moves first and then the domestic firm chooses their quantity sequentially in the final stage. Then, the first-order condition of the domestic firm to maximize its own objective function in (1) provides the reaction function of the domestic firm. By substituting this reaction function to the profit function of the foreign firm in (3) and solving the first-order condition, we obtain the following equilibrium output levels:

$$q_D^{\mathrm{SF}} = \frac{5+2\alpha-\alpha^2+t(3-4\alpha+\alpha^2)}{(7-\alpha)(3-\alpha)},\ q_F^{\mathrm{SF}} = \frac{2-t(3-\alpha)+\alpha}{7-\alpha} \tag{13}$$

where the superscript SF represents the Stackelberg game with the foreign firm's leadership.

Substituting the equilibrium outputs yields the following results:

$$\pi_D^{SF} = \frac{(5+t(3-\alpha)(1-\alpha)+(2-\alpha)\alpha)(15-(16-3\alpha)\alpha+t(9-\alpha^2))}{2(7-\alpha)^2(3-\alpha)^2}, \pi_F^{SF} = \frac{(2+t(-3+\alpha)-\alpha)^2}{2(-7+\alpha)(-3+\alpha)}$$
$$CS^{SF} = \frac{(11+2t(-3+\alpha)-3\alpha)^2}{2(-7+\alpha)^2(-3+\alpha)^2}, V_D^{SF} = \frac{25+t^2(3-\alpha)^2(1+\alpha)+(2-\alpha)\alpha(16-3\alpha)+2t(3-\alpha)(5-\alpha(9-2\alpha))}{2(7-\alpha)^2(3-\alpha)} \quad (14)$$
$$SW^{SF} = \frac{(2-\alpha)(98-\alpha(9+\alpha(16-3\alpha)))+2t(3-\alpha)(35-3\alpha(15-(7-\alpha)\alpha))-t^2(3-\alpha)^2(35-3(6-\alpha)\alpha)}{2(7-\alpha)^2(3-\alpha)^2}$$

In the second stage, using the welfare function in (14), the government decides its tariff. Then, we have the following optimal tariff in a sequential-move game with the foreign firm's leadership:

$$t^{SF} = \frac{35-45\alpha+21\alpha^2-3\alpha^3}{(3-\alpha)(35-18\alpha+3\alpha^2)} \quad (15)$$

Note again that t^{SF} is decreasing in α. Thus, the strategic tariff policy is substitutable with the domestic firm's CSR activities.

Finally, we obtain the following results:

$$q_D^{SF} = \frac{10}{35-3(6-\alpha)\alpha}, q_F^{SF} = \frac{5-3\alpha}{35-3(6-\alpha)\alpha}, \pi_D^{SF} = \frac{30(5-(5-\alpha)\alpha)}{(35-3(6-\alpha)\alpha)^2}, \pi_F^{SF} = \frac{(5-3\alpha)^2(7-\alpha)}{2(3-\alpha)(35-3(6-\alpha)\alpha)^2}$$
$$CS^{SF} = \frac{9(5-\alpha)^2}{2(35-3(6-\alpha)\alpha)^2}, V_D^{SF} = \frac{300-3(5-\alpha)\alpha(5+3\alpha)}{2(35-3(6-\alpha)\alpha)^2}, SW^{SF} = \frac{55-39\alpha+6\alpha^2}{2(3-\alpha)(35-3(6-\alpha)\alpha)} \quad (16)$$

Note again that the output of the domestic firm and consumer surplus increase, while the output of the foreign firm decreases as α increases.

(d) Comparisons

We will compare the equilibrium outcomes under the fixed-timing game. [9]

Proposition 1: The optimal tariff rate under domestic firm's leadership (foreign firm's leadership) is the lowest when α is small (large).

This proposition implies that the government will set a lower (higher) tariff rate under a domestic firm's leadership when the degree of CSR is low (high), in order to improve domestic welfare. The economic explanation is as follows: the government should take three components – consumer surplus, the domestic firm's profit, and tariff revenue – into consideration to protect the domestic market from being taken over by the foreign firm. When the degree of CSR is small, the government should take care of competition to increase consumer surplus and, thus, it will actively reduce the tariff rate to induce the domestic firm into producing outputs more aggressively. However, when the degree of CSR is high, the

[9] Some necessary proofs of propositions and lemmas are provided in Appendix A.

domestic firm will take care of consumer surplus and, thus, it will actively produce more outputs, which can substitute the output increasing effect of foreign competition, as well as increase domestic profits. Thus, the government will set the highest tariff rate to discourage a foreign firm from reducing output under a domestic firm's leadership.

Regarding the comparisons of objective functions, we have the following two lemmas.

Lemma 1: The profit of a foreign firm is highest under the foreign (domestic) firm's leadership when α is small (large).

We also hold that $\pi_F^{SF} > \pi_F^C$ for any $\alpha \in [0,1]$, while $\pi_F^C \gtreqless \pi_F^{SD}$ when $\alpha \lesseqgtr 0.8$. Lemma 1 represents a foreign firm being able to take a first-mover advantage only when the degree of CSR is not very high. This is because the domestic firm can be very aggressive in producing outputs when it participates in active CSR, which will reduce the first-mover advantage of the foreign firm. Thus, from a profitability viewpoint, the domestic firm has a strategic incentive to adopt a higher degree of CSR.[10]

Lemma 2: The objective value of a domestic firm is larger (smaller) under the domestic firm's leadership than it is under the foreign firm's leadership when α is small (large).

This shows that a domestic firm can take a first-mover advantage only when the degree of CSR is intermediate. This is because there is a cost increasing effect from higher CSR activities, which induces more production. Thus, a domestic firm can get higher objective values under the Cournot game only when the degree of CSR is low, while it can get higher objective values under a foreign leadership game when the degree of CSR is high. Note that under a foreign firm's leadership, the government will set a higher tariff, which induces more profits to the domestic firm, compared to the case of a lower tariff. We will examine the welfare comparisons.

Proposition 2: A foreign firm's leadership yields the highest welfare when the degree of CSR is intermediate, $0.347 < \alpha < 0.916$, while a domestic firm's leadership yields the highest welfare otherwise.

Proposition 2 represents that the Cournot game is never socially desirable, irrespective of the degree of CSR. This is because the leadership competition with CSR initiatives provides more outputs production and increases consumer surplus compared to the Cournot game. Further, from Proposition 1, this implies that CSR initiatives can work to improve welfare by reducing the tariff.

We can also examine the optimal promotion level of CSR activities in the following.

[10] Recent studies show that strategic CSR initiatives can increase a firm's profitability (see, e.g., Lambertini and Tampieri, 2015; Liu *et al.*, 2015; Hirose *et al.*, 2017; Leal *et al.*, 2018; Xu and Lee, 2018; Lee and Park, 2019; Garcia *et al.*, 2019).

Proposition 3: In the case of the welfare-maximizing degree of CSR, $\alpha^C = \alpha^{SD} = 0.8$ is socially optimal under both Cournot and the domestic firm's leadership games, while $\alpha^{SF} \approx 0.741$ under the foreign firm's leadership game.

This implies that the CSR activities of a domestic firm can be beneficial to society when an appropriate regulatory framework for the promotion of CSR is implemented. Therefore, the active role of governmental guidelines in promoting CSR, rather than considering it as a voluntary activity, is imperative.[11]

4. ENDOGENOUS-TIMING GAME

(a) Equilibrium Analysis

We now discuss the first stage of the choice in an endogenous-timing game. In particular, as proposed by Hamilton and Slutsky (1990), we consider an observable delay game with a pre-play period, in which the two firms endogenously determine the order of their moves prior to the actual choice of production. Specifically, there are two possible time periods for output choice, and each firm chooses its output in only one of the two periods. Then, each firm i ($i = D, F$) simultaneously chooses whether to move early ($T_i = 1$) or late ($T_i = 2$). If both firms choose the same period, it yields the equilibrium of a simultaneous-move game under the agreed timing. Otherwise, the equilibrium in a sequential-move game emerges. Table 1 provides the payoff matrix of the observable delay game.

Table 1: the payoff matrix of the observable delay game: a domestic firm participate in CSR

Firm D/F	$T_F = 1$	$T_F = 2$
$T_D = 1$	$(V_D^C,\ \pi_F^C)$	(V_D^{SD}, π_F^{SD})
$T_D = 2$	$(V_D^{SF},\ \pi_F^{SF})$	$(V_D^C,\ \pi_F^C)$

Using Lemma 1 and Lemma 2, we can obtain the following propositions:

Proposition 4: In the presence of a domestic firm's CSR: (i) when α is small ($\alpha < 0.8$), one simultaneous-move outcome, $(T_D, T_F) = (1,1)$ is the unique equilibrium outcome. (ii) when α is large ($\alpha > 0.8$), either a sequential-move with a domestic firm's leadership outcome, $(T_D, T_F) = (1,2)$ or a

[11] CSR promotion has recently become a policy agenda priority for sustainable development, and has particularly become a central policy objective in developed countries such as the United States and in the European Union (see Liu *et al.*, 2018; Xu and Lee, 2019).

sequential-move with a foreign firm's leadership outcome, $(T_D, T_F) = (2,1)$, is the equilibrium outcomes.

This shows that the equilibrium of an endogenous-timing game depends on the degree of CSR. If the degree of CSR is small, both firms coordinate to be followers, which yields the Cournot game. This indicates that when $\alpha < 0.8$, the simultaneous-move outcome as the equilibrium of an endogenous timing-game does not support the socially optimal outcome, as shown in Proposition 2.

However, if the degree of CSR is large, each firm is tempted to be a leader in increasing its objective values and thus, there exist multiple equilibrium outcomes. This indicates that when the degree of CSR is large, the simultaneous-move outcome disappears as the equilibrium of an endogenous-timing game and thus, the Cournot model in the analysis of CSR initiatives may become problematic.

These results coincide with the previous literature. For example, Hamilton and Slutsky (1990) examined two domestic firms with $\alpha = 0$ and showed that a simultaneous game is an equilibrium of an endogenous-timing game. Also, Pal (1998) examined a mixed market where one domestic firm competes with one welfare-maximizing public firm, where $\alpha = 1$, and showed that the two sequential games are equilibria of an endogenous-timing game. Hence, Proposition 4 can encompass these two extreme cases.

Proposition 5: The foreign firm's leadership equilibrium is payoff dominance (and risk dominance) when $0.8 < \alpha < 0.829$ while the domestic firm's leadership equilibrium is payoff dominance (and risk dominance) when $\alpha > 0.972$.

This proposition implies that the domestic firm's leadership equilibrium might not appear when $0 < \alpha < 0.829$, while the foreign leadership might not appear when $0.972 < \alpha < 1$. Note that the payoff dominance is sufficient to be the risk dominance in the observable delay game (see Matsumura and Ogawa, 2009).

(b) Welfare Analysis

From the profit ranks in Lemma 2, the welfare ranks in Proposition 2 and the equilibrium outcomes in Proposition 4, we have the following welfare and profit consequences (in Propositions 6 and 7) in an endogenous-timing game:

Proposition 6: In the presence of higher CSR where $\alpha > 0.916$,.the sequential-move equilibrium with a domestic firm's leadership can yield the highest welfare

This implies that higher CSR encourages the domestic firm to be more aggressive, which results in, not only the equilibrium of the endogenous-timing game, but also the highest welfare. From Proposition 2, this also implies that the profit incentive of the domestic firm and the welfare incentive of the

government can coincide in an endogenous-timing game with larger CSR. Therefore, not only is voluntary adoption of CSR by the domestic firm imperative to improving welfare, but so too is the active role of the governmental tariff. This also implies that policy agenda should be used to encourage and incentivize the adoption of CSR through appropriate regulation and fiscal incentives.[12]

On the other hand, from the viewpoint of a firm's profitability, we can raise two questions about the firm's strategic behaviors and then assess the extent to which a CSR promotion policy is imperative to improving not only welfare but also the firm's profits.

Proposition 7: In the presence of higher CSR where $\alpha > 0.8$, the profit of the domestic firm is highest under a domestic firm's leadership.

This implies that a higher degree of CSR activities by the domestic firm is also profitable to the investors of the firm. It also explains the approach of strategic CSR, in which the domestic firm is willing to adopt CSR progressively to increase its profits. Hence, the profitability initiative of the domestic firm and the welfare incentive of the government coincides and, thus, these two private and social incentives can be compatible in the strategic trade policy.

Finally, we consider the incentive for collusion between domestic and foreign firms under the strategic trade policy[13] in Appendix B and compare the welfare results with the equilibrium of the endogenous-timing game.

Proposition 8: In the presence of higher CSR where $\alpha > 0.805$, collusive behaviors between the domestic and foreign firms increase social welfare.

This indicates that collusion can yield higher welfare for society when the degree of CSR is high enough. This is because both firms' gains from cooperation do not come at the expense of consumer surplus when the degree of CSR is sufficiently large. This is quite interesting as collusion between firms usually harms to society. This result also coincides with the recent literature in Mukherjee and Sinha (2019), who consider export cartel and show that the firms' cooperation might enhance consumer surplus and improve social welfare. However, they examined the profit-maximizing cooperation without consideration of CSR. Our analysis reveals that volunatary cooperation under higher CSR by the domestic firm might not necessarily be harmful to society.

[12] For more detail on the role of governmental guidelines for promoting CSR, see Liu *et al.* (2018) and Xu and Lee (2019).

[13] Recent studies have analyzed the positive effect of firms' cooperation on social welfare (see, e.g., Symeonidis, 2008; Mukherjee, 2010; Mukherjee and Sinha, 2018).

5. CONCLUDING REMARKS

This study considered the CSR initiatives of a domestic firm in the context of strategic tariff policy and examined how the degree of CSR activities induce the equilibrium outcome of endogenous choice on a different market competition. The main findings are as follows. First, the strategic tax rate under the simultaneous-move game is highest when the degree of CSR is small, while that under the sequential-move game with a domestic firm's leadership is highest otherwise. Second, sequential-move games with a domestic firm's leadership yields the highest welfare when the degree of CSR is high while a foreign firm's leadership yields the highest welfare when the degree of CSR is intermediate. Third, a simultaneous-move outcome is the unique equilibrium when the degree of CSR is small, but it is never socially desirable. Fourth, a domestic firm's leadership can be an equilibrium of the endogenous-timing game, which results in the largest social welfare when the degree of CSR is large. Therefore, not only is voluntary adoption of CSR by the domestic firm imperative to improving social welfare, but so too is the active role of governmental guideline for strategic tariff and promoting CSR. Finally, when the degree of CSR is large, the collusive behaviors between the domestic and foreign firms also increase social welfare.

However, our analysis has a limitation because of the simple duopoly structure of our modeling with linear demand and quadratic cost functions. There should be further examination in a more general model of an oligopoly setting in the context of different strategies, such as price and quality within the framework of differentiated products.[14] Finally, it is necessary to investigate a real-world situation and analyze the effects of governmental intervention on CSR behaviors. In particular, additional examination should be performed into the situation where the global firm adopts CSR and enters the domestic market, and how the difference in CSR activities can substitute or complement the strategic tariff policy. These are challenging areas for future research.

REFERENCES

Aaronson, S. (2007). A Match made in the corporate and public interest: marrying voluntary CSR initiatives and the WTO. *Journal of World Trade*, 41(3), 629–659.

[14] In the literature on an endogenous-timing game with duopoly firms, the results are mostly reversed depending on whether firms compete for price or quantity, as well as whether firms compete in a private or mixed duopoly (see, e.g., Matsumura and Ogawa, 2014; Ghosh and Mitra, 2014; Liu *et al.*, 2015; Haraguchi and Matsumura, 2016; Xu *et al.*, 2016; Fanti and Buccella, 2018; Wang *et al.*, 2018). Recent analyses by Lee and Xu (2018) and Garcia *et al.* (2019) further show that equilibrium also depends on the degree of environmental concerns.

Chang, Y.M., Chen, H.Y., Wang, L.F.S., & Wu, S.J. (2014). Corporate social responsibility and international competition: a welfare analysis. *Review of International Economics,* 22, 625–638.

Chao, A.C., Lee, J.Y., & Wang, L.F.S. (2016). Corporate social responsibility, trade liberalization and global welfare', In: Santos, Pauline (Ed.), Trade Liberalization: Global Policies, Benefits and Economic Risks. Nova Science Publishers, 25–36

Fanti, L., & Buccella, D. (2018). Corporate social responsibility and the choice of price versus quantities. *Japan and The World Economy,* 48, 71-78.

Garcia, A., Leal, M., & Lee, S.H. (2018). Time-inconsistent environmental policies with a consumer-friendly firm: tradable permits versus emission tax. *International Review of Economics and Finance,* 58, 523–537

Garcia, A., Leal, M., & Lee, S.H. (2019). Endogenous timing with a socially responsible firm. *Korea Economic Review*, forthcoming

Ghosh, A., & Mitra, M. (2014). Reversal of Bertrand-Cournot rankings in the presence of welfare concerns. *Journal of Institutional and Theoretical Economics,* 170, 496–519.

Hamilton, J.H., & Slutsky, S.M. (1990). Endogenous timing in duopolyg games: Stackelberg or Cournot equilibria. *Games and Economic Behavior,* 2, 29–46.

Haraguchi, J., & Matsumura, T. (2016). Cournot–Bertrand comparison in a mixed oligopoly. *Journal of Economics,* 117, 117–136.

Hirose, K., Lee, S. H., & Matsumura, T. (2017). Environmental corporate social responsibility: a note on the first-mover advantage under price competition. *Economics Bulletin,* 37(1), 214–221.

KPMG, 2015). International survey of corporate responsibility reporting 2015.

Lambertini, L., & Tampieri, A. (2015). Incentives, performance and desirability of socially responsible firms in a Cournot oligopoly. *Economic Modelling,* 50, 40–48.

Leal, M., Garcia, A., & Lee, S.H. (2018). The Timing of environmental tax policy with a consumer-friendly firm. *Hitotsubashi Journal of Economics,* 59(1), 25-43.

Lee, S.H., & Park, C.H. (2019). Eco-firms and the sequential adoption of environmental corporate social responsibility in the managerial delegation. *The B.E. Journal of Theoretical Economics*, 19, 1-9

Lee, S.H., & Xu, L. (2018). Endogenous timing in private and mixed duopolies with emission taxes. *Journal of Economics,* 124, 175–201.

Liu, C.C., Wang, L., & Lee, S.H. (2015). Strategic environmental corporate social responsibility in a differentiated duopoly market. *Economics Letters,*129, 108–111.

Liu, Q. Wang, L.F.S., & Chen, C.L. (2018). CSR in an oligopoly with foreign competition: policy and welfare implications. *Economic Modelling*, 72, 1-7

Manasakis, C., Mitrokostas, E., & Petrakis, E. (2018). Strategic corporate social responsibility by a multinational firm. *Review of International Economics,* 26, 709–720

Matsumura, T., & Ogawa, A. (2009). Payoff dominance and risk dominance in the observable delay game: a note. *Journal of Economics,* 97, 265–272.

Matsumura, T., & Ogawa, A. (2014). Corporate social responsibility or payoff asymmetry? a study of an endogenous timing game. *Southern Economic Journal,* 81, 457–473.

Mukherjee, A. (2010). Product market cooperation, profits and welfare in the presence of labor union. *Journal of Industry, Competition and Trade,* 10, 151-160.

Mukherjee, A., & Sinha, U.B. (2019). Export cartel and consumer welfare. *Review of International Economics,* 27(1), 91-105

Pal, D. (1998). Endogenous timing in a mixed oligopoly. *Economics Letters,* 61, 181–185.

Symeonidis, G. (2008). Downstream competition, bargaining and welfare. *Journal of Economics and Management Strategy*, 17, 247-270.

Vidal-Leon, C., (2013). Corporate social responsibility, human rights, and the WTO. *Journal of International Economic Raw,* 16, 4, pp. 893-920.

Xu, L., Cho, S., & Lee, S.H. (2016). Emission tax and optimal privatization in Cournot-Bertrand comparison. *Economic Modelling,* 55, 73–82.

Xu, L., & Lee, S.H. (2018). Environmental policies with excess burden of taxation in free-entry mixed markets. *International Review of Economics and Finance,* 58, 1-13.

Xu, L., & Lee, S.H. (2019). Tariffs and privatization policy in a bilateral trade with corporate social responsibility. *Economic Modelling*, https://doi.org/10.1016/j.econmod.2018.11.020

Wang, L. F. S., Wang, Y. C., & Zhao, L. (2012). Tariff policy and welfare in an international duopoly with consumer-friendly initiative. *Bulletin of Economic Research*, 64(1), 56–64.

Wang, C. Nie, P.Y. & Meng Y. (2018). Duopoly competition with corporate social responsibility. *Austrian Economic Papers,* 57(3), 327-345

APPENDIX A: THE PROOFS

Proof of Lemma 1: (i) If $0 < \alpha < 0.8$ then $\pi_F^{SF} > \pi_F^C > \pi_F^{SD}$ (ii) If $0.8 < \alpha < 0.829$ then $\pi_F^{SF} > \pi_F^{SD} > \pi_F^C$ (iii) If $0.829 < \alpha < 1$ then $\pi_F^{SD} > \pi_F^{SF} > \pi_F^C$.

Proof of Lemma 2: (i) If $0 < \alpha < 0.315$ then $V_D^C > V_D^{SD} > V_D^{SF}$ (ii) If $0.315 < \alpha < 0.796$ then $V_D^{SD} > V_D^C > V_D^{SF}$ (iii) If $0.796 < \alpha < 0.8$ then $V_D^{SF} > V_D^{SD} = V_D^C$ (iv) If $0.8 < \alpha < 0.926$ then $V_D^{SF} > V_D^{SD} > V_D^C$ (v) If $\alpha > 0.926$ then $V_D^{SD} > V_D^{SF} > V_D^C$.

Proof of Proposition 1: (i) If $0 < \alpha < 0.600$ then $t^C > t^{SF} > t^{SD}$ (ii) If $0.600 < \alpha < 0.8$ then $t^C > t^{SD} > t^{SF}$ (iii) If $\alpha > 0.8$ then $t^{SD} > t^C > t^{SF}$.

Proof of Proposition 2: (i) $\mathrm{SW}^{SF} > \mathrm{SW}^{SD} > \mathrm{SW}^{C}$ when $0.348 < \alpha < 0.916$ (ii) $\mathrm{SW}^{SD} > \mathrm{SW}^{SF} > \mathrm{SW}^{C}$ otherwise.

Proof of Proposition 5: From Lemma 1 and Lemma 2, (i) we have $V_D^{SF} > V_D^{SD}$ and $\pi_F^{SF} > \pi_F^{SD}$ when $0.8 < \alpha < 0.829$, which yields payoff dominance of foreign firm's leadership, and $(V_D^{SF} - V_D^{C})(\pi_F^{SF} - \pi_F^{C}) > (V_D^{SD} - V_D^{C})(\pi_F^{SD} - \pi_F^{C})$ when $0.796 < \alpha < 0.972$, which yields risk dominance of foreign firm's leadership. (ii) we have $V_D^{SF} < V_D^{SD}$ and $\pi_F^{SF} < \pi_F^{SD}$ when $\alpha > 0.926$, which yield payoff dominance of domestic firm's leadership, and $(V_D^{SF} - V_D^{C})(\pi_F^{SF} - \pi_F^{C}) < (V_D^{SD} - V_D^{C})(\pi_F^{SD} - \pi_F^{C})$ when either $\alpha < 0.796$ or $\alpha > 0.972$, which yields risk dominance of domestic firm's leadership .

Proof of Proposition 7: (i) If $0 < \alpha < 0.461$ then $\pi_D^{C} > \pi_D^{SD} > \pi_D^{SF}$ (ii) If $0.461 < \alpha < 0.642$ then $\pi_D^{C} > \pi_D^{SF} > \pi_D^{SD}$ (iii) If $0.642 < \alpha < 0.8$ then $\pi_D^{C} > \pi_D^{SD} > \pi_D^{SF}$ (iv) If $0.8 < \alpha < 1$ then $\pi_D^{SD} > \pi_D^{C} > \pi_D^{SF}$.

Proof of Proposition 8: (i) $\mathrm{SW}^{SD} > \mathrm{SW}^{SF} > \mathrm{SW}^{C} > \mathrm{SW}^{Co}$ when $\alpha < 0.348$ (ii) $\mathrm{SW}^{SF} > \mathrm{SW}^{SD} > \mathrm{SW}^{C} > \mathrm{SW}^{Co}$ when $0.348 < \alpha < 0.793$ and (iii) $\mathrm{SW}^{SF} > \mathrm{SW}^{Co} > \mathrm{SW}^{SD} > \mathrm{SW}^{C}$ when $0.793 < \alpha < 0.805$ (iv) $\mathrm{SW}^{Co} > \mathrm{SW}^{SF} > \mathrm{SW}^{SD} > \mathrm{SW}^{C}$ when $0.805 < \alpha < 0.916$ (v) $\mathrm{SW}^{Co} > \mathrm{SW}^{SD} > \mathrm{SW}^{SF} > \mathrm{SW}^{C} >$ when $\alpha > 0.916$

APPENDIX B: COLLUSION

In the following analysis of output choices in the last stage, we assume that both firms choose the output simultaneously to maximize their joint objectives, $V_D + \pi_F$, defined in (1) and (3). Then, from the first-order conditions, we obtain the following collusion outputs:

$$q_D^{\mathrm{Co}} = \frac{1+t(2-\alpha)}{5-2\alpha},\ q_F^{\mathrm{Co}} = \frac{1-t(3-\alpha)}{5-2\alpha}$$
$$\pi_D^{\mathrm{Co}} = \frac{(1+t(2-\alpha))(5-(4-t)\alpha)}{2(5-2\alpha)^2},\ \pi_F^{\mathrm{Co}} = \frac{(1-t(3-\alpha))(5-4\alpha-t(5-3\alpha))}{2(5-2\alpha)^2} \quad \text{(B1)}$$

where the superscript Co represents collusion. Substituting these outpts yields the followings:

$$\mathrm{CS}^{\mathrm{Co}} = \frac{(2-t)^2}{2(5-2\alpha)^2},\ V_D^{\mathrm{Co}} = \frac{5+t(10-(4(4-\alpha)-t(3-\alpha))\alpha)}{2(5-2\alpha)^2}$$
$$\mathrm{SW}^{\mathrm{Co}} = \frac{9+4t(2-\alpha)^2-4\alpha-t^2(29-(24-5\alpha)\alpha)}{2(5-2\alpha)^2} \quad \text{(B2)}$$

In the second stage, using the welfare function in (B2), the government decides its optimal tariff.

$$t^{\mathrm{Co}} = \frac{2(2-\alpha)^2}{29-\alpha(24-5\alpha)} \quad \text{(B3)}$$

Note again that t^{Co} is decreasing in α. Finally, we can obtain the following outcomes under collusion:

$$q_D^{\mathrm{Co}} = \frac{(3-\alpha)^2}{29-\alpha(24-5\alpha)}, q_F^{\mathrm{Co}} = \frac{1+(2-\alpha)\alpha}{29-\alpha(24-5\alpha)}$$

$$\pi_D^{\mathrm{Co}} = \frac{(3-\alpha)^2(29-\alpha(34-9\alpha))}{2(29-\alpha(24-5\alpha))^2}, \pi_F^{\mathrm{Co}} = \frac{(1+(2-\alpha)\alpha)(21-\alpha(26-7\alpha))}{2(29-\alpha(24-5\alpha))^2} \quad \text{(B4)}$$

$$\mathrm{CS}^{\mathrm{Co}} = \frac{2(5-2\alpha)^2}{(29-\alpha(24-5\alpha))^2}, V_D^{\mathrm{Co}} = \frac{261-\alpha(380-9\alpha(26-(8-\alpha)\alpha))}{2(29-\alpha(24-5\alpha))^2}, \mathrm{SW}^{\mathrm{Co}} = \frac{13-(8-\alpha)\alpha}{58-2\alpha(24-5\alpha)}$$

Note that not only the outputs of domestic and foreign firms but consumer surplus increase as α increases. Finally, from the comparisons with equations in (12), (16) and (B4), we can show that: $SW^{SD} < SW^{Co}$ when $\alpha > 0.793$ and $SW^{SF} < SW^{Co}$ when $\alpha > 0.805$. This means that when $\alpha > 0.805$, collusion can yield higher welfare for the society.

APPENDIX C: FOREIGN FIRM'S CSR

We consider a counterpart case where a domestic firm maximizes its profit while a foreign firm adopts CSR and maximizes the following objectives: $V_F = \pi_F + \beta\,\mathrm{CS}$ where $\beta \in [0,1]$ denotes the weights assigned to consumer surplus. Then, the equilibrium results under the foreign firm's CSR are described as * and summarized in Table C1. Note that Co* represents the collusive case where both firms choose the output to maximize their joint objectives, $\pi_D + V_F$.

We will provide a few findings in the following Propositions and compare with the results under the domestic firm's CSR.

Proposition C1: The optimal tariff under domestic firm's leadership (foreign firm's leadership) is the lowest when β is small (large).

Proof: (i) If $0 < \beta < 0.186$, then $t^{C*} > t^{SF*} > t^{SD*}$ (ii) If $0.186 < \beta < 0.968$, then $t^{C*} > t^{SD*} > t^{SF*}$ (iii) if $\beta > 0.968$, then $t^{SD*} > t^{C*} > t^{SF*}$.

Proposition C2: Domestic firm's leadership yields the highest welfare for any $\beta \in [0,1]$ while foreign firm's leadership is the lowest welfare when β is large. .

Proof: (i) *If* $0 < \beta < 0.389$, then $SW^{SD*} > SW^{SF*} > SW^{C*}$ (ii) *If* $\beta > 0.389$, then $SW^{SD*} > SW^{C*} > SW^{SF*}$.

Proposition C3: In the case of the welfare-maximizing degree of CSR, $\beta = 1$ is the socially optimal for any competition mode, i.e., $\beta^{C*} = \beta^{SD*} = \beta^{SF*} = 1$.

Proposition C4: In the presence of foreign firm's CSR, (i) When β is small ($\beta < 0.134$), one simultaneous-move outcome, $(T_D, T_F) = (1,1)$ is the unique equilibrium outcome (ii) When $0.134 < \beta < 0.688$, there is no equilibrium. (iii) When β is $0.688 < \beta < 0.698$, one sequential-move with foreign firm leadership outcome, $(T_D, T_F) = (2,1)$ is the unique equilibrium (iv) When β is large ($\beta >$

0.698), either sequential-move with domestic firm leadership outcome, $(T_D, T_F) = (1, 2)$ or sequential-move with foreign firm leadership outcome, $(T_D, T_F) = (2, 1)$ are the equilibrium outcome.

Proof: The profits ranks of domestic firm is: (i) If $0 < \beta < 0.688$, then $\pi_D^{C*} > \pi_D^{SD*} > \pi_D^{SF*}$ (ii) If $0.688 < \beta < 0.698$, then $\pi_D^{C*} > \pi_D^{SF*} > \pi_D^{SD*}$ (iii) If $0.698 < \beta < 0.929$, then $\pi_D^{SF*} > \pi_D^{SD*} > \pi_D^{C*}$ (iv) if $\beta > 0.929$, then $\pi_D^{SF*} > \pi_D^{SD*} > \pi_D^{C*}$. The objective value ranks of foreign firm is: (i) If $0 < \beta < 0.134$, then $V_F^{SF*} > V_F^{C*} > V_F^{SD*}$ (ii) if $\beta > 0.134$, then $V_F^{SF*} > V_F^{SD*} > V_F^{C*}$

Proposition C5: When $\beta > 0.698$, the foreign firm's leadership equilibrium is payoff dominance (risk dominance as well).

Proof: From the profit of domestic firm and the objective value of foreign firm, we can show that $V_F^{SF*} > V_F^{SD*}$ and $\pi_D^{SF*} > \pi_D^{SD*}$ when $0.688 < \beta < 1$. We can also show that when $\beta > 0.698$, then $(V_F^{SF*} - V_F^{C*})(\pi_D^{SF*} - \pi_D^{C*}) > (V_F^{SD*} - V_F^{C*})(\pi_D^{SD*} - \pi_D^{C*})$.

Proposition C6: In the presence of higher CSR where $\beta > 0.698$, the sequential-move equilibrium with domestic firm's leadership can yield the highest welfare.

Proof: $(T_D, T_F) = (1, 2)$ or $(T_D, T_F) = (2, 1)$ is the equilibrium outcome when $\beta > 0.698$ and $SW^{SD*} > SW^{C*} > SW^{SF*}$ when $\beta > 0.389$.

Proposition C7: In the presence of higher CSR where $\beta > 0.698$, the profit of domestic firm is the highest under the foreign firm leadership.

Proof: From Proposition 4, π_D^{C*} is the highest when $\beta < 0.697$ while $\pi_D^{SF*}$is the highest otherwise.

Proposition C8: The collusive behaviors between the domestic and foreign firms always decrease the welfare.

Proof: (i) If $0 < \beta < 0.389$, then $SW^{SD*} > SW^{SF*} > SW^{C*} > SW^{Co*}$. (ii) If $\beta > 0.389$, then $SW^{SD*} > SW^{C*} > SW^{SF*} > SW^{Co*}$

Proposition C8 shows that collusion always harms to the society when foreign firm adopts CSR. This result is sharply contrast to the collusion case when domestic firm adopts CSR in Proposition 8.

Table C1. The Equilibrium Outcomes under Foreign Firm's CSR

	Cournot Model	Domestic Firm's Leadership	Foreign Firm's Leadership	Collusion
Tariff	$t^{C*}=\frac{14+\beta-2\beta^2}{41-12\beta}$	$t^{\mathrm{SD}*}=\frac{92-\beta(23+\beta(27-(11-\beta)\beta))}{290-2\beta(112-\beta(27-2\beta))}$	$t^{\mathrm{SF}*}=\frac{105-8\beta^2}{315-72\beta}$	$t^{\mathrm{Co}*}=\frac{2(2-\beta)^2}{29-\beta(24-5\beta)}$
Output	$q_D^{C*}=\frac{12-5\beta}{41-12\beta}$ $q_F^{C*}=\frac{5+3\beta}{41-12\beta}$	$q_F^{\mathrm{SD}*}=\frac{17+\beta(4-(6-\beta)\beta)}{145-\beta(112-\beta(27-2\beta))}$ $q_D^{\mathrm{SD}*}=\frac{(3-\beta)(32-3(7-\beta)\beta)}{290-2\beta(112-\beta(27-2\beta))}$	$q_D^{\mathrm{SF}*}=\frac{10(3-\beta)}{3(35-8\beta)}$ $q_F^{\mathrm{SF}*}=\frac{5+2\beta}{35-8\beta}$	$q_D^{\mathrm{Co}*}=\frac{(3-\beta)^2}{29-\beta(24-5\beta)}$ $q_F^{\mathrm{Co}*}=\frac{1+(2-\beta)\beta}{29-\beta(24-5\beta)}$
Profit	$\pi_D^{C*}=\frac{3(12-5\beta)^2}{2(41-12\beta)^2}$ $\pi_F^{C*}=\frac{(5+3\beta)(15-\beta(25-4\beta))}{2(41-12\beta)^2}$	$\pi_D^{\mathrm{SD}*}=\frac{(7-\beta)(3-\beta)(32-3(7-\beta)\beta)^2}{8(145-\beta(112-\beta(27-2\beta)))^2}$ $\pi_F^{\mathrm{SD}*}=\frac{(17+\beta(4-(6-\beta)\beta))(51-\beta(118-\beta(69-(15-\beta)\beta)))}{2(145-\beta(112-\beta(27-2\beta)))^2}$	$\pi_D^{\mathrm{SF}*}=\frac{50(3-\beta)^2}{3(35-8\beta)^2}$ $\pi_F^{\mathrm{SF}*}=\frac{(5+2\beta)(105-2\beta(69-8\beta))}{18(35-8\beta)^2}$	$\pi_D^{\mathrm{Co}*}=\frac{(3-\beta)^2(29-\beta(34-9\beta))}{2(29-\beta(24-5\beta))^2}$, $\pi_F^{\mathrm{Co}*}=\frac{(1+(2-\beta)\beta)(21-\beta(26-7\beta))}{2(29-\beta(24-5\beta))^2}$
Consumer Surplus	$\mathrm{CS}^{C*}=\frac{(17-2\beta)^2}{2(41-12\beta)^2}$	$\mathrm{CS}^{\mathrm{SD}*}=\frac{(130-\beta(87-(18-\beta)\beta))^2}{8(145-\beta(112-\beta(27-2\beta)))^2}$	$\mathrm{CS}^{\mathrm{SF}*}=\frac{(45-4\beta)^2}{18(35-8\beta)^2}$	$\mathrm{CS}^{\mathrm{Co}*}=\frac{2(5-2\beta)^2}{(29-\beta(24-5\beta))^2}$
The Objective Value of Foreign Firm	$V_F^{C*}=\frac{(75-16\beta)(1+(3-\beta)\beta)}{2(41-12\beta)^2}$	$V_F^{\mathrm{SD}*}=\frac{(3-\beta)(1156+3616\beta-5808\beta^2+3187\beta^3-835\beta^4+105\beta^5-5\beta^6)}{8(145-112\beta+27\beta^2-2\beta^3)^2}$	$V_F^{\mathrm{SF}*}=\frac{525+\beta(1545-556\beta+48\beta^2)}{18(35-8\beta)^2}$	$V_F^{\mathrm{Co}*}=\frac{(3-\beta)(7+\beta(41-7(5-\beta)\beta))}{2(29-\beta(24-5\beta))^2}$
Social Welfare	$\mathrm{SW}^{C*}=\frac{21-(2-\beta)\beta}{82-24\beta}$	$\mathrm{SW}^{\mathrm{SD}*}=\frac{154-\beta(92-\beta(23-(6-\beta)\beta))}{580-4\beta(112-\beta(27-2\beta))}$	$\mathrm{SW}^{\mathrm{SF}*}=\frac{165-4(3-\beta)\beta}{630-144\beta}$	$\mathrm{SW}^{\mathrm{Co}*}=\frac{13-(8-\beta)\beta}{58-2\beta(24-5\beta)}$