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We use a game theoretic approach to assess how the government can influence firms' CSR investment and production decisions to enhance social welfare, considering the negative externalities brought by unsustainable production and positive externalities brought by CSR investments. Using a Stackelberg duopoly as a base model and lump-sum tax as the government's decision variable, we find that when the government chooses not to intervene, it results in greater environmental damage as firms will underinvest in CSR and overproduce in quantity to achieve profit maximization. As such, the model extends to the assumption that the government acts as a benevolent dictator to model how firms will act under a regulated environment to achieve the Pareto optimal outcome. Ultimately, we show that firms have to be placed under a regulated environment to prevent them from exploiting resources and damaging the environment, thereby negatively affecting societal welfare.

1. INTRODUCTION

Over the years, it has been evident that the manufacturing sector has flourished; however, along with this, came the negative externalities on the environment. These negatively contribute to the wellbeing of society; hence, there is a need to hold firms accountable for their actions (Allen & Craig, 2016). Nonetheless, several firms are still reluctant to invest in environmental CSR as it can be costly and risky in the short-run, specifically in the absence of an external force, which is the government (Chen & Hu, 2018).

Our objective is to assess how government intervention can affect firms' investment and production decisions by using a game theoretic approach set under a Stackelberg duopoly. The findings will hopefully generate insights that may aid the government in implementing policy frameworks that may induce firms to adopt sustainable production and aid in the sustainable decision-making of firms. This may also provide further insights for future studies.

However, this study is limited on the influence of government intervention through the imposition of a lump-sum tax, which affects the overall model, and compares the outcomes with an extension of the model where the government acts as a benevolent dictator that will decide the firms' levels of production and CSR investments, with the objective of enhancing social welfare. Moreover, we use a dynamic non-repetitive three-player Stackelberg game, particularly taking into account the role of the government as the regulator and decisions of competing manufacturers in the same industry.

2. LITERATURE REVIEW

CSR increases firm performance by enhancing stakeholder trust (Rjiba et al., 2020), consumer perception (Bardos et al., 2020), firm value, and market share brought by an enhanced corporate reputation (Barnea & Rubin, 2010). CSR also contributes to product differentiation (Lee & Jung, 2016; Fanti & Buccella, 2016) and positively influences demand as more consumers globally have started favoring environment-friendly products (Garcia-Gallego & Georgantiz, 2009). The trade-off, however, would be the incurrence of quadratic costs from CSR investment that leads to a short-term decrease in firm profitability (Garcia-Gallego & Georgantiz, 2009; Zhu & Li, 2013). Despite this, a consumer preference towards sustainability yields higher profits for firms that invest in CSR and it improves social welfare in most cases (Garcia-Gallego & Georgantiz, 2009). Likewise, the most optimal solution for firms would always be to undertake CSR for the long run (Zhu & Li, 2013).

Studies have utilized a Stackelberg duopoly approach in studying the decisions of firms in adopting environmental CSR. Under a quantity competition, Sharma (2018) presented that each firm has an incentive to invest in CSR as a strategy; hence, if the cost of CSR does not exceed a certain threshold, then the equilibrium outcome is both firms investing in CSR. The leader firm ultimately receives higher profits than the follower firm as it obtains a greater market share and enjoys its first-mover advantage. However, as the decisions of firms to invest in CSR is not always the case, governments are encouraged to take the relevant role as drivers of CSR (Lee, et al., 2017).

Considering the presence of government intervention, studies present that taxes are effective in reducing environmental damage (Walter & Chang, 2019; Chen & Hu, 2018); and promoting sustainable methods (Chen et al., 2019; Krass et al., 2013). However, the effectiveness of tax in promoting CSR is dependent on the price sensitivity of consumers and society's level of environmental concern (Krass, et al., 2013). Meanwhile, contrasting results are obtained on the effect of tax on social welfare. Under a Cournot duopoly competition, although

emission tax successfully increases social welfare when it is set at an equal rate to marginal damages (Walter & Chang, 2019), pollution tax leads to a contrasting result (Chen et al., 2019). Although pollution tax also decreases output quantity, firm profits, and consumer surplus (Chen et al., 2019), simultaneously offering subsidies will help in offsetting the mentioned outcomes. Likewise, a combined policy of taxes and subsidies will be most effective in promoting green technologies and maximizing social welfare (Chen & Hu, 2018; Krass et al., 2013).

3. FRAMEWORK

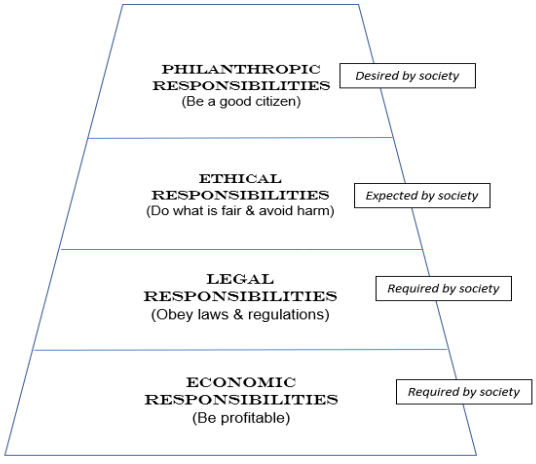
The general economic frameworks used to form the foundation and guide us in formulating the model based on assumptions made are as follows:

Stackelberg Game
Stackelberg games are non-symmetric games that are similar to the normal Cournot game. The difference lies in the decision-making order, where one player or specified group of players have the privileged position and make decisions before the other players. The standard model of sequential choices is the Stackelberg quantity leadership model with linear demand, where leaders' actions are informative about market conditions and independent of leaders' beliefs about the arrivals of followers (Wilczyński et al., 2016).

Carroll's CSR Pyramid
Carroll's CSR pyramid depicts the nature of the CSR engagement of firms. There are four types of social responsibilities: economic, legal, ethical, and philanthropic. The framework implies that the categories lower down on the pyramid carry heavier weight and should be the organisation's main goals when implementing a CSR (Carroll, 2016). Figure 1 portrays the four components of CSR.

The pyramid illustrates the building block nature of the four-part framework. Though separated, they are not mutually exclusive but instead fulfilled simultaneously. The positioning intent is to show the fundamentals and nature of the categories in business existence as viewed by society. Any CSR-driven firm should be profitable, law-abiding, engage in ethical practices, and be a good corporate citizen (Carroll, 2016).

Figure 1
Carroll's CSR Pyramid



Intervention Theory.
The intervention theory analyses the decision-making problem at hand, weighing out both its consequences and benefits to intervene effectively, resulting in the desired outcomes. It answers the question of whether it is appropriate and beneficial to intervene or not. Moreover, it examines the effectiveness of intervening in different ways. Standard intervention theory is applied through a 3-step process. The first step is to identify the evidence base of the dilemma. The second step is to develop the theory through design intervention and creating realistic expectations; lastly, to model the process and the potential outcomes (Aromatario et al., 2019).

Theory of Optimal Deterrence
The optimal deterrence theory explains the regulation of undesirable acts and assumes that rational individuals seek to avoid punishments. Any actions aimed toward deterring behavior are made under the assumption that increasing the punishment will decrease the targeted behavior. It also takes into account how people respond to incentives. The goal is to investigate how the government may achieve its objective given the individual decision-making strategy. The theory generally assumes that individuals are informed of the situation and are rational agents who act under the assumption that they yield private benefits in excess of all costs of acting. When the act's external harm exceeds its private gain, the act is socially undesirable and should be deterred at the lowest social cost (Raskolnikov, 2019).

4. METHODOLOGY

The following are the assumptions made to help structure and direct the researchers towards making and solving the functional forms:

1. The players will have access to complete information, and when making decisions, they are rational and risk-neutral.
2. Production technology and prices are homogenous.
3. Demand is downward sloping in price but upward sloping in CSR degree.
4. The level of CSR engagement affects the cost of CSR.
5. The profits of the firms are affected by fixed unit production costs, tax, and the cost of CSR investment.
6. The government seeks to maximize social welfare, which includes the profit of both firms, consumer surplus, aggregate tax, and environmental quality. Environmental quality is negatively affected by production levels and positively affected by the investment in CSR.

Figure 2
Structure of the Game

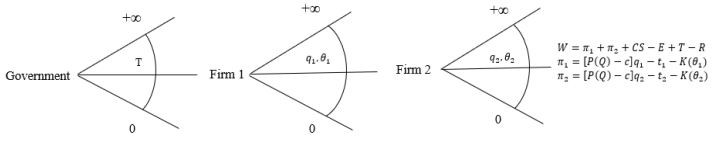


Figure 2 presents the basic structure of the game. The game consists of three players: the government, the leader firm and the follower firm. Following the Stackelberg game, the leader firm, being Firm 1, is more powerful than the follower firm, being Firm 2. Firm 1 will consider the reaction function of Firm 2 in

determining its optimal output and CSR investment, thus exhibiting the Stackelberg duopoly; the government intervenes by means of imposing taxes to regulate firm actions.

There are two stages of the game: (a) In stage 1, the government decides how much to intervene by determining the lump-sum tax, (b) in the 2nd stage, firms will compete and determine how much quantity to produce and how much CSR to invest in.

Using backward induction, Stage 2 is solved first, where the reaction functions of Firm 2 with regards to Firm 1's level of production and CSR investment are obtained. These are then factored into the decision-making of Firm 1 to solve the optimization problem of maximizing its profit. The resulting values for q_1^* and θ_1^* are then substituted into Firm 2's reaction functions to obtain q_2^* and θ_2^*. Through this, the subgame perfect nash equilibrium (SPNE) outcomes are obtained, and the values for firm profits and consumer surplus can be solved.

Moving on to Stage 1 of the game, the government decides the level of lump-sum tax that would maximize social welfare given the SPNE outcomes from Stage 1. This results in $T^* = 0$, indicating that the firms and society are better off when the government does not intervene at all. However, this result may have been due to the functional forms and assumptions used in the model. As such, some form of government intervention is modeled to compare the results by way of modeling the government as a benevolent dictator that maximizes social welfare by deciding the aggregate output and CSR investment for the market. As discussed in the following section, this extension results in Pareto optimal outcomes and, thus, the SPNE results are deemed as the second-best outcome.

5. RESULTS AND DISCUSSION

PROPOSITION 1. If $0 < \psi, \zeta < 1$ and $\psi > \zeta$, then $q_1^* > q_2^*$, $\theta_1^* < \theta_2^*$, and $\pi_1^* > \pi_2^*$.

Proof.

$q_1^* - q_2^* = \frac{A(1-\psi)}{2-(\beta^2/k)\zeta} > 0$; hence, $q_1^* > q_2^*$

$\theta_1^* - \theta_2^* = \frac{A\beta(\zeta-\psi)}{k[2-(\beta^2/k)\zeta]} < 0$; hence, $\theta_1^* < \theta_2^*$

$\pi_1^* - \pi_2^* = \frac{A^2[\zeta(2k-\beta^2\zeta k-\psi]}{2k[2-(\beta^2/k)\zeta]^2} > 0$; hence, $\pi_1^* > \pi_2^*$

and considering the set parameters: $A \equiv a - c$, $a > c$, $\beta^2 < k$, $0 < \beta < 1$, and $\boldsymbol{k > 1}$. □

The findings follow the Stackelberg conditions where the quantity produced by the leader firm is greater than that of the follower firm as Firm 1 obtains a greater market share, and enjoys its first-mover advantage. As CSR positively influences consumer demand, Firm 2 invests in a relatively higher level of CSR than Firm 1 to maximize its profit and further differentiate itself from the leading firm. However, Firm 1 still generates the largest profits as it keeps its dominant position in the market as shown by its first-mover advantage. Nonetheless, this does not lead to a Pareto optimal outcome.

PROPOSITION 2 If $d = k$ and $d, k > 1$, then $Q^o < Q^*$, and $\Theta^o > \Theta^*$

Proof.

$$Q^o - Q^* = \frac{A(d+k)}{(1+d)(d+k)+(\beta+d)^2} - \frac{A[3-(\beta^2/k)]\psi}{[2-(\beta^2/k)\zeta]} = \frac{A[(d+k)\eta-[3-(\beta^2/k)]\psi\gamma]}{\gamma\eta} < 0;\ \text{hence, } Q^o < Q^*$$

$$\Theta^o - \Theta^* = \frac{A(\beta+d)}{(1+d)(d+k)+(\beta+d)^2} - \frac{A\beta(\psi+\zeta)}{k[2-(\beta^2/k)\zeta]} = \frac{A[(\beta+d)\gamma-\beta(\psi+\zeta)\eta]}{\gamma k\eta} > 0;\ \text{hence, } \Theta^o > \Theta^*$$

and considering the set parameters for the following variables: $d = k > 1$, $\beta^2 < k$, $0 < \beta < 1$, $\psi > \zeta$, $\gamma > \eta$, $A \equiv a - c$, and $a > c$ □

Therefore, $Q^o < Q^*$ and $\Theta^o > \Theta^*$. Following Proposition 2, it is then shown that when firms are left to decide on how to conduct their own operations, they will choose the option that will ultimately benefit them more through incurring the least possible cost and the highest possible profit, considering their nature as a profit-maximizing firm. Given this, they will independently choose to produce more to sell more while neglecting the negative impact they bring to the environment; hence, underinvesting in CSR.

Consequently, when $Q^o < Q^*$, then it follows that $CS^* > CS^o$ and $\Pi^* > \Pi^O$. This shows that without government intervention to boost the adoption of CSR, consumers will be able to derive consumer benefits from lower product prices from firms who underinvest in CSR, while firms will be able to generate a larger amount of profit when the government decides not to intervene as firms are able to produce and sell a relatively larger quantity.

Therefore, it may be noted that societal welfare is positively influenced when firms are left unregulated due to higher profit brought by larger production capacities and higher consumer surplus. However, it does not automatically lead to greater societal welfare due to the counter effects of negative environmental externalities brought by unsustainable production.

PROPOSITION 3. If $Q^o < Q^*$ and $\Theta^o > \Theta^*$, then $E^*(Q, \Theta) > E^o(Q, \Theta)$

Proof.

Given that $E(D) = \frac{d}{2}(D^2) = \frac{d}{2}(Q - \Theta)^2$, then

$$E^*(Q, \Theta) = \frac{d}{2}(Q^o - \Theta^o)^2 > \frac{d}{2}(Q^* - \Theta^*)^2 = E^o(Q, \Theta)$$

following Proposition 2 that $Q^o < Q^*$ and $\Theta^o > \Theta^*$. □

Given the assumption that the environmental quality is positively affected by the level of CSR investments and negatively affected by the production levels of manufacturing firms, it then follows that when firms underinvest in CSR and overproduce in quantity under an unregulated corporate environment, then environmental damage is further aggravated.

6. CONCLUSION

The worsening environmental conditions and their effects have been felt more and more by society. With this, consumers have become more interested in supporting companies with environmentally-friendly products or production practices to slow down the deterioration of the environment. However, firms are still deterred from taking advantage of this shift in consumer demand due to the additional costs, which may not be compensated by the returns on their investment in the short run. As such, there is a need for a regulating body, specifically the government, to encourage the firms to invest more in CSR. Thus, we show the behavior of the firms with regard to their production and CSR investment in a Stackelberg duopoly in the presence of government intervention.

This model has resulted in three propositions: first, both firms exhibit the Stackelberg structure where the leader firm produces more and receives higher profits. However, we find that the follower firm invests more in CSR and that the government does not intervene by not imposing a lump-sum tax on the firms. Second, by assuming that the government acts as a benevolent dictator that decides the production and CSR investment of both firms, aggregate output is lower, and aggregate CSR investment is higher than if they do not intervene at all. Third, when the government acts as a benevolent dictator, it is able to mitigate the environmental damage caused by firm productions.

This emphasizes the importance of CSR as a business strategy and tool to improve social welfare, as well as the importance of government intervention to control firm behavior and minimize environmental damage to society. The results support existing literature and add to it by focusing on firms under a Stackelberg duopoly, with the government as a regulating body to mitigate unsustainable production.

However, there are potential weaknesses in our study that can be improved for future research. For one, the non-repetitive nature of the game and the assumption of the government as a benevolent dictator do not model real-life situations. Moreover, the use of lump-sum taxes as the government's decision variable failed to illustrate how tax can influence firm behavior. The results of our study may have also been limited by its assumptions and the specific functional forms used, which led to suboptimal results in the original game.

Regardless, we show the importance of the government in influencing firm behavior. As such, future researchers can use different intervention schemes such as imposing per-unit taxes, subsidies, or a combination of both. They may also consider variations in the cost of CSR to see its effect on the players. Different functional forms can also be used to see if the results would hold and if the outcome would still be suboptimal. Moving forward, both policymakers and researchers must carefully study their countries to create specific policies that would best fit their economic landscapes to maximize their benefit to society.

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