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Corporate social responsibility, profits, and welfare in a duopolistic market

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Abstract: We consider a two-stage game in a differentiated duopoly, where firms can pursue both a financial and an environmental objective. We assume that the maximum willingness-to-pay of consumers increases with the weights given by firms to their environmental objective. In the first stage of the game, the firms decide on the weight of their environmental objective and, in the second stage, firms compete à la Cournot. We show that accounting for environmental concerns in the firms’ objective is generally profitable, and that lower pollution and higher profits can be attained in equilibrium when the impact of firms’ environmental conscientiousness on consumers’ willingness to pay is above a given threshold that depends on the products substitutability parameter. However, we find that the impact of firms’ environmental awareness on consumers’ welfare is ambiguous.

Résumé: Nous étudions un jeu séquentiel à deux étapes dans un duopole de produits substituables en considérant que les firmes peuvent poursuivre un double objectif. À la première étape, les firmes décident du poids qu’elles accordent à l’objectif environnemental, alors qu’à la deuxième étape, elles décident des quantités qu’elles mettent en marché. Nous supposons que la propension à payer des consommateurs croît avec le poids que les firmes accordent à l’objectif de protection de l’environnement. Nous montrons que la conscience environnementale est généralement profitable pour les firmes, et qu’on peut réduire la pollution et atteindre des profits plus élevés à l’équilibre lorsque l’impact de la conscience environnementale des entreprises sur la propension à payer des consommateurs dépasse un certain seuil, qui dépend du degré de substituabilité des produits.

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1 Introduction

On April 11, 2019, the French National Assembly amended the Civil Code in order to give greater consideration to social and environmental issues in companies’ strategies and activities. While initially article 1833 of the Civil Code stated that “every firm must have lawful objects and be formed in the common interest of the members,” it now expressly mentions that each firm must also take into consideration social and environmental issues. Thus, to comply with the law, firms must pursue multiple objectives. It remains to be seen how effective will this new law be in changing firms’ behavior (there is, after all, a difference between paying attention and actually addressing social and environmental issues). This amendment also created a new legal status, entreprise à mission (purpose driven company). This legal status requires a firm, not only to generate profit for its shareholders, but also to do so in a way that affects social and environmental issues.\(^1\) For instance, in June 2020, Danone became France’s first large listed company to adopt this new legal status. Danone shareholders voted to enshrine the group’s mission to bring “health through food” to consumers into its corporate bylaws.

In addition to legal requirement, social pressures also incite firms to pursue multiple objectives. For instance, some companies may wish to demonstrate leadership and responsibility by announcing their participation in the effort to reduce greenhouse gas accumulation. In many cases, Corporate Social Responsibility (CSR) has become an instrument to attract consumers, who are increasingly considering social responsibility as important attributes in their choice of products.

This paper contributes to a growing literature on oligopolistic competition in a CSR context.\(^2\) We specifically contribute to the study of the strategic motivation for corporate social responsibility, as introduced in Baron (2001) and McWilliams & Siegel (2001). That is, we take the view that firms are not altruistic per se. Rather, firms behave in a socially responsible way when they find that doing so is profitable. In that spirit, we address two research questions:

i) Under what conditions is it profitable for firms to behave in a socially responsible way?

ii) Assuming that these conditions are met, is the adoption of CSR policies welfare improving for their customers?

To answer these questions it is useful to consider models where the firms’ level of CSR is endogenous.\(^3\) There are many ways to do that, depending on how social responsibility is defined (e.g. consumer surplus, pollution abatement) and on the market structures considered.\(^4\)

As to market structures, some papers consider the vertical model of a supply channel where the products are complements (Goering, 2014; Brand & Grothe, 2015; Garciá et al., 2018; Fanti & Buccella, 2020), while others examine CSR in a monopolistic competition setting (Giallonardo & Mulino 2016). These contributions all assume that a socially responsible firm cares for consumers’ surplus. Deltas et al. (2013) consider a horizontally differentiated duopoly, where consumers care about the product’s “greenness” and where firms can differ in their chosen level of greenness, and notably show that greenness is underprovided.

Our paper contributes to the stream of literature that considers vertical differentiation, where the consumers’ willingness to pay (WTP) is affected by the firms’ level of CSR. García-Gallego & Georgantzis (2010) assume that firms use CSR as vertical differentiation strategy and study market structures ranging from monopoly to duopoly with complete market coverage. CSR is not defined

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\(^1\)\(^{This \ new \ legal \ status \ is \ akin \ to \ the \ Benefit \ Corporations \ in \ the \ U.S. \ See \ Segrestin \ et \ al., \ 2020, \ for \ an \ overview \ of \ the \ new \ French \ corporate \ legal \ status \ and \ of \ its \ relationships \ with \ other \ corporate \ forms \ recently \ introduced \ in \ various \ countries.}\)

\(^2\)\(^{See \ Kitzmuller \ & \ Shimshack \ (2012) \ and \ Schmitz \ & \ Schrader \ (2015) \ for \ surveys \ of \ the \ literature \ on \ CSR.}\)

\(^3\)\(^{There \ exist \ a \ significant \ stream \ of \ literature \ that \ studies \ the \ effects \ of \ CSR \ by \ assuming \ that \ some \ or \ all \ of \ the \ firms \ are \ socially \ responsible. \ See \ for \ instance \ Conrad \ (2005), \ Rodriguez-Ibeas \ (2007), \ Yanase \ (2013), \ Wirl \ et \ al. \ (2013) \ and \ Lambertini \ et \ al. \ (2020).}\)

\(^4\)\(^{Other \ issues \ relate \ to \ whether \ the \ approach \ is \ dynamic, \ like \ the \ evolutionary \ approach \ in \ Königstein \ & \ Müller \ (2001), \ Planer-Friedrich \ & \ Sahm \ (2015) \ and \ Kopel \ & \ Lamantia \ (2018), \ or \ whether \ a \ certification \ process \ is \ involved, \ as \ in \ Liu \ et \ al. \ (2015).}\)
precisely, apart from the fact that it entails an additional cost for the firm. The authors find that, in most cases, (exogenous) increases in the consumers’ social consciousness yield higher profits to socially responsible firms, and may lead to higher levels of social welfare, provided that the market structure is left unchanged. However, when an increase in the consumers’ social consciousness changes the market structure, welfare may fall, while one of the duopolists’ profits rise.

Doni & Ricchiuti (2013) also obtain mixed results regarding the welfare effect of CSR, defined as the level of polluting emissions’ abatement, according to the nature of the abatement cost function. If the costs of the cleaning process are fixed, then social welfare is increasing in consumers’ WTP and in firms’ CSR. On the other hand, social welfare may be reduced by an increase of consumers’ WTP and/or firms’ CSR when the abatement costs are variable.

Two recent contributions address the issue at hand in the standard Cournot competition framework. In both cases, the level of CSR is defined as the weight firms put on consumers’ surplus in their objective function, before deciding upon supply. In a symmetric setting, Planer-Friedrich & Sahm (2020a) show that the endogenous level of CSR is positive, for any given number of firms. However, positive CSR levels imply smaller equilibrium profits. They also find that an incumbent monopolist can use CSR as an entry deterrent (so that CSR may increase market concentration). Planer-Friedrich and Sahm (2020b) consider a Cournot duopoly where firms differ in their marginal costs of production. The authors show that the most efficient firm chooses a higher CSR level, reinforcing its dominant position. If the (fixed) cost of CSR are sufficiently high, only the more efficient firm will engage in CSR.

In this paper, we rather relate CSR to environmental concerns, so that firms may choose to adhere to an environmentally responsible policy reducing their production level (and therefore their polluting emissions). We suppose that consumers value the environmental consciousness of firms, which increases their WTP. We consider a differentiated duopoly à la Dixit (1979) and Singh & Vives (1984), where an increase in the weight assigned by a given firm to an environmental objective increases the quality (vertical) differentiation of its product. We model the interactions in the differentiated duopoly as a two-stage game. In the first stage, firms decide to consider or not the reduction of pollution as an objective in their production decision, and environmentally concerned firms decide on the relative importance of the weights assigned to the profit and to the reduction of pollution. In the second stage of the game, competing firms decide on their production levels.

We show that, when the consumers’ WTP for environmental consciousness is above a given threshold that depends on the products substitutability parameter, the Nash equilibrium is Pareto improving for the firms, so that it is profitable for them to announce a reduction in their output for environmental considerations. However, we find that consumer’s welfare does not always increase when firm engage in (profit driven) socially responsible behavior.

The paper is organized as follows. In Section 2, we lay out the main ingredients of our model. Section 3 solves for the equilibrium quantities when firms have already chosen their level of CSR. Section 4 solves for the equilibrium CSR strategy, examining under what conditions firms would find it profitable to choose a positive level of CSR. Section 5 addresses the impact of CSR on consumers’ surplus. Section 6 briefly concludes the paper.

2 Model

We consider a differentiated Cournot duopoly, where firms may decide to pursue a double objective: profit maximization and minimization of pollution. We analyze a two-stage game, where, in a first stage, firms announce their pollution awareness level (which could be 0), and, in the second stage, firms compete in quantity.

Let \( q_i \) denote the production level of Firm \( i, i \in \{1, 2\} \). In the sequel, \( j = 3 - i \). The production cost of a quantity \( q_i \) by Firm \( i \) is equal to \( c_i q_i \). Production by firms produces pollution, which we assume proportional to the production level. The pollution awareness level of Firm \( i \) is characterized...
by the relative weight used for the two attributes (profit v.s. contribution to pollution) in its objective function.

Accordingly, the objective function used by Firm \(i\) to decide on its production level in the second stage of the game is

\[
\pi_i(q; \mu_i) = \mu_i q_i (p_i - c_i) - (1 - \mu_i) q_i, \ i \in \{1, 2\},
\]

where \(p_i\) is the market price of good \(i\) and \(\mu_i \in (0, 1]\) characterizes the relative importance of both attributes for Firm \(i\). Define \(d_i = \frac{1 - \mu_i}{\mu_i} \in [0, \infty)\). The parameter \(d_i\) characterizes the degree of environmental awareness of a firm; a firm with \(d_i = 0\) maximizes pure profit, while an environmentally conscious firm has a positive \(d_i\).

Following Dixit (1979) and Singh and Vives (1984), the representative consumer’s utility function is assumed quadratic strictly concave and is given by

\[
U(q_i, q_j, y) = a_i q_i (1 + k d_i) + a_j (1 + k d_j) q_j - \frac{b_i q_i^2}{2} - \frac{b_j q_j^2}{2} - \gamma q_i q_j + y,
\]

where \(y\) is a composite good, and \(a_i, a_j, k, b_i\) and \(b_j\) are positive parameters (products are substitutes). The coefficient \(k\) indicates that the representative consumer values the environmental consciousness of firms, so that \(d_i\) increases the quality (vertical) differentiation of product \(i\) and the consumers’ willingness to pay.

The strict concavity of the representative consumer’s utility function assumption implies that

\[
\gamma^2 < b_1 b_2.
\]

To ensure that the maximum utility of the consumer is achieved in the positive quadrant, we further assume that:

\[
\gamma < \min_{i \in \{1, 2\}} \left\{ b_i \frac{a_i + k_i d_i}{a_i + k_i d_i} \right\},
\]

The representative consumer maximizes her utility under the budget constraint

\[
p_i q_i + p_j q_j + y = I.
\]

This yields the inverse demand functions for \(i \in \{1, 2\}\)

\[
p_i = \max \{0; a_i + k_i d_i - b_i q_i - \gamma q_j\}.
\]

As usual in the economics literature, we further assume that own price effect is larger than the cross price effect,

\[
\gamma < b_i, \ i \in \{1, 2\},
\]

which ensures that condition (2) is satisfied.

As a consequence, the profit of Firm \(i\) is given by

\[
\pi_i(q_i, q_j) = \max \{0; q_i (p_i - c_i)\}
= \max \{0; q_i (m_i + k_i d_i - b_i q_i - \gamma q_j)\},
\]

where \(m_i = a_i - c_i > 0\). We further assume that

\[
\gamma < \frac{b_j m_i}{m_j} \text{ for } i \in \{1, 2\},
\]

\(5\)Here, we assume that the environmental objective of Firm \(i\) is related to its own polluting emissions. Using the total duopoly emissions instead would not change anything in the results.

\(6\)The assumption that consumers’ willingness to pay increases with the product’s “greenness” or with the level of the producer’s CSR is used in many papers; see, for instance, Conrad (2005), Doni & Ricchiuti (2013) and Deltas et al. (2013).
which ensures that, when firms have no environmental concern \((d_1 = d_2 = 0)\), the Cournot equilibrium of the differentiated duopoly is interior.

Condition 3 requires that the impact of environmental consciousness on consumers’ willingness to pay be bounded. Specifically, we will analyze the impact of the following assumptions on the value of parameter \(k\):

\[
k_i = ka_i < 1 \quad \text{for } i \in \{1, 2\} \quad (6)
\]

\[
L_i = 4b_1b_2k_i - \gamma^2 > 0 \quad \text{for } i \in \{1, 2\}. \quad (7)
\]

### 3 Second-stage equilibrium

For a given environmental awareness vector \(d\), given that firms pursue a double objective as indicated in (1), the reaction function of Firm \(i\) to a production level \(q_j\) by the rival firm is

\[
q_i(q_j; d) = \max \left\{0; m_i - \gamma q_j - d_i \left(1 - k_i\right) \right\}. 
\]

Condition (6) ensures that the production of Firm \(i\) is decreasing in its environmental awareness level \(d_i\); in the sequel, we assume that Condition (6) is satisfied.

Assuming an interior solution, the corresponding equilibrium solution for \(i \in \{1, 2\}\) is

\[
q_i(d) = r_1i d_i + r_2i d_j + r_3i, \quad (8)
\]

with

\[
r_{1i} = \frac{-2b_j \left(1 - k_i\right)}{K} < 0
\]

\[
r_{2i} = \frac{\gamma \left(1 - k_j\right)}{K} > 0
\]

\[
r_{3i} = \frac{2b_jm_i - \gamma m_j}{K} > 0
\]

\[
K = 4b_1b_2 - \gamma^2 > 0, \quad i \in \{1, 2\},
\]

indicating that an increase in the environmental concern of Firm \(i\) will lead to a reduction of its production and resulting pollution in equilibrium, but to an increase in the production of the competing firm. Corresponding equilibrium prices are given by

\[
p_i(d) = f_{1i} d_i + f_{2i} d_j + f_{3i},
\]

with

\[
f_{1i} = \frac{2b_i b_j \left(k_i + 1\right) - \gamma^2}{K} > 0,
\]

\[
f_{2i} = \frac{\gamma b_i \left(1 - k_j\right)}{K} > 0
\]

\[
f_{3i} = c_i + b_i \frac{2b_j m_i - \gamma m_j}{K} > 0,
\]

indicating that an increase in the environmental concern of Firm \(i\) will lead to an increase of the price of both products in equilibrium.

### 4 First-stage equilibrium

In the first stage of the game, firms select their environmental concern parameter by maximizing their profit, accounting for the fact that reducing polluting emissions will have a positive impact on the
consumers’ demand. The profit of Firm $i$ corresponding to weights $d = (d_i, d_j)$ is then

$$\pi_i(d) = q_i(d) \left( m_i + k_id_i - b_iq_i(d) - \gamma q_j(d) \right),$$

where the quantities $q_i(d)$ are the equilibrium solutions of the duopoly game, obtained in Equation (8). Since the equilibrium strategies are linear in $d_i$ and $d_j$, the resulting objective functions of firms are quadratic:

$$\pi_i = s_{1i}d_i^2 + s_{2i}d_j^2 + s_{3i}d_id_j + s_{4i}d_i + s_{5i}d_j + s_{6i},$$

where

$$s_{1i} = r_{1i}(k_i - b_i r_{1i} - \gamma r_{2j})$$

$$= -2b_j(1 - k_i) \frac{2b_j b_j - \gamma^2 + 2b_j b_j k_i}{K^2} < 0$$

$$s_{2i} = -r_{2i}(b_i r_{2i} + \gamma r_{1j})$$

$$= \gamma^2 b_i (1 - k_j)^2 > 0$$

$$s_{3i} = \left(r_{2i}(k_i - 2b_i r_{1i}) - \gamma (r_{1i} r_{1j} + r_{2i} r_{2j})\right)$$

$$= L_i \gamma (1 - k_j)$$

$$s_{4i} = \left(k_i r_{3i} + r_i (m_i - 2b_i r_{3i}) - \gamma (r_i r_{3j} + r_{3i} r_{2j})\right)$$

$$= L_i \left(2b_j m_i - \gamma m_j\right)$$

$$s_{5i} = \left(r_{2i}(m_i - 2b_i r_{3i}) - \gamma (r_{1j} r_{3i} + r_{2i} r_{3j})\right)$$

$$= 2\gamma (1 - k_j) b_i \frac{2b_j m_i - \gamma m_j}{K^2} > 0$$

$$s_{6i} = r_{3i}(m_i - b_i r_{3i} - \gamma r_{3j})$$

$$= b_i \left(2b_j m_i - \gamma m_j\right)^2 > 0.$$

Notice that $s_{3i}$ and $s_{4i}$ are positive when conditions (6) and (7) are satisfied.

We now compute the equilibrium profits and production corresponding to three possible scenarios, where firms can decide to include or not an environmental weight in their objective function.

### 4.1 No environmental weight

The first scenario is the benchmark case where none of the firms announce an environmental policy, so that $d_i = d_j = 0$. The equilibrium solution of the duopoly game and corresponding equilibrium profit are then, for $i \in \{1, 2\}$

$$q_i^B = r_{3i} > 0$$

$$p_i^B = f_{3i} > 0$$

$$\pi_i^B = s_{6i} > 0.$$

### 4.2 One environmentally concerned firm

In the second scenario, only Firm $i$ chooses to announce an environmental policy, so that $d_j = 0$. The optimization problem of Firm $i$ is concave since $s_{1i} < 0$. The optimal level of environmental awareness for Firm $i$ is then given by

$$d_i^* = \max \left\{ 0, -\frac{s_{4i}}{2s_{1i}} \right\}$$
\[
\frac{2b_j m_i - \gamma m_j}{4b_j (1 - k_i) (2b_i b_j - \gamma^2 + 2b_i b_j k_i)} \max \{0, L_i\}.
\]

Note that \(d_i^* > 0\) under Assumption (7) while \(d_i^* = 0\) if \(L_i \leq 0\). The equilibrium solution of the duopoly game under (7) is

\[
q_i^* = r_1 d_i^* + r_3 i = \frac{1}{2} \frac{2b_j m_i - \gamma m_j}{2b_i b_j (k_i + 1) - \gamma^2} > 0,
\]

\[
q_j^* = r_2 d_i^* + r_3 j > 0.
\]

Proposition 1 Under Assumption (7), when only Firm \(i\) is environmentally conscious, it produces less than in the benchmark case, while its rival increases its production. Total pollution is lower and both firms’ prices and profits are higher than in the benchmark case.

Proof.

1. Impact on quantities:

\[
q_i^* - q_i^B = r_1 d_i^* < 0
\]

\[
q_j^* - q_j^B = r_2 d_i^* > 0
\]

\[
Q_i^* - Q_i^B = d_i^* (r_1 + r_2) > 0
\]

\[
= -d_i^* \left(1 - k_i \frac{2b_j - \gamma}{K}\right) < 0.
\]

2. Impact on prices:

\[
p_i^* - p_i^B = f_1 d_i^* > 0
\]

\[
p_j^* - p_j^B = f_2 d_i^* > 0.
\]

3. Impact on profit:

\[
\pi_i^* - \pi_i^B = d_i^* (s_{4i} + d_i^* s_{1i})
\]

\[
= -\frac{1}{4} s_{4i}^2 > 0
\]

\[
\pi_j^* - \pi_j^B = d_i^* (d_i^* s_{2j} + s_{5j}) > 0.
\]

\[
\square
\]

4.3 Two environmentally concerned firms

In the third scenario, we assume that both firms choose their environmental awareness parameters independently. Since \(s_{1i} < 0\), the optimization problem of each firm is concave. For a given \(d_j\), the impact of \(d_i\) on Firm \(i\)'s profit is given by

\[
\frac{d\pi_i}{dd_i} = 2s_{1i} d_i + s_{3i} d_j + s_4 i = 2s_{1i} d_i + L_i \frac{\gamma (1 - k_j) d_j + L_i (2b_j m_i - \gamma m_j) K^2}{K^2}.
\]

Note that when \(L_i \leq 0\), Firm \(i\)'s profit is decreasing in \(d_i\) for any \(d_j \geq 0\). The equilibrium value for the environmental parameter of Firm \(i\) is then \(d_i = 0\) and the solution reduces to the scenario analyzed the preceding paragraph. Otherwise, the best response of Firm \(i\) satisfies

\[
d_i = -\frac{s_{1i} d_i + s_{4i}}{2s_{1i},} > 0.
\]
Accordingly, under Assumption (7), the equilibrium solution is
\[ d_i^N = \frac{s_{3i} s_{4j} - 2s_{1j}s_{4i}}{4s_{1i}s_{1j} - s_{3i}s_{3j}} > 0, \] (16)
with \( q_i^N > 0 \) for \( i \in \{1, 2\} \) (see the Appendix).

**Proposition 2** Under Assumption (7), when both firms decide on the weight of pollution damage independently, the impact with respect to the benchmark case is a decrease of the total production, and an increase in the profit of both firms.

**Proof.**

Impact on production:
\[
Q^N - Q^B = d_i^N (r_{2j} + r_{1i}) + d_j^N (r_{2i} + r_{1j}) = -d_i^N \frac{(1 - k_i) (2b_j - \gamma)}{K} - d_j^N \frac{(1 - k_j) (2b_i - \gamma)}{K} < 0.
\]

Impact on prices:
\[
p_i^N - p_i^B = f_{1i} d_i^N + f_{2j}^N d_j > 0.
\]

Impact on profit:
\[
\pi_i^N - \pi_i^B = s_{1i} (d_i^N)^2 + s_{2i} (d_j^N)^2 + s_{3i} d_i^N d_j^N + s_{4i} d_i^N + s_{5i} d_j^N
= s_{1i} (d_i^N)^2 + s_{2i} (d_j^N)^2 + s_{3i} d_i^N d_j^N + (-2s_{1j} d_i^N - s_{3j} d_j^N) d_i^N + s_{5j} d_j^N
= -s_{1i} (d_i^N)^2 + s_{2i} (d_j^N)^2 + s_{5j} d_j^N > 0.
\]

\[ \square \]

### 4.4 Equilibrium

Using the above results, the first stage of the duopoly game corresponds to the following matrix game
\[
\begin{array}{c|cc}
   & d_2 = 0 & d_2 > 0 \\
 d_1 = 0 & (\pi_1^N, \pi_2^N) & (\pi_1^N, \pi_2^N) \\
 d_1 > 0 & (\pi_1^N, \pi_2^N) & (\pi_1^N, \pi_2^N),
\end{array}
\]
where the entries correspond to the equilibrium profits of the three possible scenarios. We will consider three cases according to the sign of \( L_i, i \in \{1, 2\} \).

#### 4.4.1 Sufficiently high impact in both markets

The following proposition shows that when Assumption (7) is satisfied for \( i \in \{1, 2\} \), that is, when the impact of environmental consciousness is sufficiently high in both markets, the Nash equilibrium where both firms choose to announce an environmental policy using a positive environmental weight is Pareto improving and corresponds to the best outcome for both firms.

**Proposition 3** Under Assumption (7), the Nash equilibrium of the two-stage game corresponds to the pair \( (d_1^N, d_2^N) \), which results in a lower pollution level and a higher profit for both firms with respect to the benchmark case and to the case where only one firm is environmentally conscious.

**Proof.** We already showed that \( (d_1^N, d_2^N) \) is the Nash equilibrium when Assumption (7) is satisfied (Equation 16). We now show that \( (d_1^N, d_2^N) \) results in a lower pollution level and is Pareto improving.
\( d^N_i > d^i_1 : \)

\[
d^N_i - d^i_1 = \frac{s_{3i}s_{4i}}{4s_{1i}s_{1j} - s_{3i}s_{3j}} - \frac{2s_{1j}s_{4i}}{2s_{1i}} + \frac{s_{4i}}{2s_{1i}} \\
= -\frac{1}{2}s_{3i}\frac{s_{4i}s_{3j}}{s_{1i}(4s_{1i}s_{1j} - s_{3i}s_{3j})} \\
= -\frac{1}{2}s_{3i}\frac{d^N_i}{s_{1i}} > 0.
\]

\( Q^N < Q^i : \)

\[
Q^N - Q^i = (d^N_i - d^i_1)(r_{2j} + r_{1i}) + d^N_j(r_{2i} + r_{1j}) \\
= - (d^N_i - d^i_1) \left( \frac{2b_j - \gamma}{K} \right) - d^N_j \left( \frac{2b_i - \gamma}{K} \right) \\
< 0.
\]

\( \pi^N_i > \pi^i_1 > \pi^B_i : \)

\[
\pi^N_i - \pi^i_1 = s_{1i} \left( d^N_i \right)^2 + s_{2i} \left( d^N_j \right)^2 + s_{3i}d^N_i d^N_j + s_{4i}d^N_i + s_{5i}d^N_j - \left( s_{1i} \left( d^i_1 \right)^2 + s_{4i}d^i_1 \right) \\
= (d^N_i - d^i_1) \left( s_{1i} \left( d^N_i + d^i_1 \right) \right) + s_{3i}d^N_i d^N_j + s_{4i}d^N_i + s_{5i}d^N_j + s_{4i} \left( d^N_i - d^i_1 \right) \\
= \left( -\frac{1}{2}s_{3i}\frac{d^N_i}{s_{1i}} \right) \left( s_{1i} \left( d^N_i + d^i_1 \right) \right) + s_{3i}d^N_i d^N_j + s_{4i} \left( d^N_i - d^i_1 \right) + s_{3i}d^N_i d^N_j + s_{5i}d^N_j + s_{5i} \\
= \frac{1}{2} \left( 2s_{4i} + d^N_j s_{3i} \right) \left( d^N_i - d^i_1 \right) + d^N_j \left( s_{2i}d^N_j + s_{5i} \right) > 0
\]

4.4.2 Low impact in both markets

When consumers do not value environmental consciousness, or when the value of \( k \) is relatively low, that is,

\[
k \leq \min_i \left\{ \frac{\gamma^2}{4b_1b_2a_i} \right\},
\]

neither firms finds it profitable to adhere to an environmental policy, and the equilibrium in the first stage of the game is \( d_1 = d_2 = 0 \), which corresponds to the classical equilibrium in a differentiated duopoly.

4.4.3 Sufficient impact in one market

When there is a significant quality differentiation between the two markets and when the value of \( k \) is large enough, that is, if

\[
\frac{\gamma^2}{4b_1b_2a_i} < k \leq \frac{\gamma^2}{4b_1b_2a_j},
\]

then the firm in the market with the highest choke price \( a_i \) finds it profitable to announce that it will reduce its output in order to limit its contribution to pollution. The equilibrium in the first stage is then \( (d_1 > 0, d_2 = 0) \) which results in a lower global pollution and a higher profit for both firms than the classical differentiated duopoly equilibrium, as shown in Proposition 1.
4.5 When is it profitable for firms to behave in a socially responsible way?

We have shown in Propositions 1 and 3 that when \( L_i > 0 \), Firm \( i \) will find it profitable to reduce its production and its polluting emissions, which will result in a higher profit for both firms and in a lower global pollution level. Note that this behavior differs from greenwashing. Firms do behave in a socially responsible way, including an environmental objective in their profit function, and do reduce their polluting emissions, provided that the impact in the consumers’ willingness to pay, represented by the parameter \( k \), is sufficiently high. The threshold value for \( k \) is increasing in the substitutability parameter \( \gamma \): a higher \( k \) is required when products are highly substitutable.\(^7\) We also find that the reduction in polluting emissions results in a price increase for both products, which may lead to a decrease in consumers’ welfare. This issue is investigated in the following section.

5 Impact on consumers’ welfare

Recall the utility of a representative consumer who values the environmental consciousness of firms competing in quantity and offering substitutable products:

\[
U(q_i, q_j) = a_i q_i (1 + kd_i) + a_j (1 + kd_j) q_j - \frac{b_i q_i^2}{2} - \frac{b_j q_j^2}{2} - \gamma q_i q_j.
\]

Using Equation (8), the utility of consumers can be expressed as a quadratic function of the environmental awareness parameters \((d_i, d_j)\). It can be shown that the second partial derivatives of \( U(d_i, d_j) \) with respect to \( d_i \) and \( d_j \) are both negative, but \( U \) is not necessarily concave. Moreover, \( U \) is not necessarily increasing in \( d_i \) or \( d_j \) at \((0,0)\).

Assuming Condition (7) is satisfied, it is possible to find sets of parameters yielding, in equilibrium, an increase or a decrease in the consumers’ welfare with respect to the benchmark case, as illustrated in the following table.

<table>
<thead>
<tr>
<th>( k )</th>
<th>( d )</th>
<th>( q )</th>
<th>( P )</th>
<th>( \pi )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>48.43</td>
<td>34.87</td>
<td>0.697</td>
<td>24.32</td>
</tr>
<tr>
<td>( k = 0.10 )</td>
<td>46.21</td>
<td>27.60</td>
<td>0.986</td>
<td>27.20</td>
</tr>
<tr>
<td>( k = 0.25 )</td>
<td>76.33</td>
<td>20.64</td>
<td>2.807</td>
<td>57.94</td>
</tr>
</tbody>
</table>

Table 1: Illustration of the impact of CSR on consumers’ welfare. Parameter values are: \( a_1 = 3, a_2 = 2.4, c_1 = 1.5, c_2 = 1, \gamma = 0.01, b_1 = 0.02 \text{ and } b_2 = 0.05 \). The equilibrium solution is computed for \( k = 0.1 \) and for \( k = 0.25 \).

In this specific example, Product 1 has a higher choke price, marginal production cost and unit margin than Product 2, while the demand is more sensitive to the price of Product 1 than to that of Product 2. In the benchmark Cournot equilibrium, the supply of Product 1 is higher, and its price is lower than that of Product 2. When consumers value environmental consciousness moderately \((k = 0.1)\), both firms find it profitable to reduce their supply and increase their prices, which results in a decrease of the consumers’ utility. When the consumers put a higher value on environmental consciousness \((k = 0.25)\), firms put a higher weight on the environmental objective, reducing their supply and increasing their prices even more, which results in an increase of the consumers’ utility.\(^8\)

6 Conclusion

We have shown that, when consumers value CSR, it is possible for firms to attain higher profits and reduce their contribution to pollution in equilibrium, provided that the representative consumer’s

\(^7\)Note that when products are independent \((\gamma = 0)\), \( L_i \) is strictly positive for any feasible \( k \).

\(^8\)Note that this behavior is specific to the parameter values, since the utility of consumers in equilibrium is not monotone in \( k \) in general.
impact parameter $k$ be above a given threshold that depends on the degree of product substitutability. The condition allowing for at least one firm adhering to a production reduction policy is

$$k > \frac{\gamma^2}{4b_1b_2a_i},$$

where the threshold is increasing in $\gamma$ and decreasing in $a_i$. We also have shown that, in equilibrium, such a reduction in supply can increase or decrease consumers’ utility, depending on the parameter values.

Those results are in line with empirical evidence on French firms reported in Pekovic et al. (2018). The authors study the effect of environmental investments on economic performance, measured by firms’ net profits, and show that this effect follows an almost U-inverted curve, implying that there is an optimal level of environmental investment. The portion of the curve where investing in greenness improves profits is small and the optimal point is quickly reached, implying that, for most firms, only “limited” green investments are profitable.

**Appendix**

We show that when $L_1 > 0$ and $L_2 > 0$, $d^N_i > 0$ and $q^N_i > 0$ for $i \in \{1, 2\}$.

1. $d^N_i > 0$

$$d^N_i = \frac{s_{3i}s_{4j} - 2s_{1j}s_{4i}}{(4s_{1i}s_{1j} - s_{3i}s_{3j})}$$

where

$$s_{3i} > 0, s_{4i} > 0, s_{1i} < 0 \text{ for } i \in \{1, 2\}$$

and

$$4s_{1i}s_{1j} - s_{3i}s_{3j} = (k_i - 1)(k_j - 1) \frac{\gamma^4 + 4b_ib_j(4b_ib_j(k_j + 1)(k_i + 1) - \gamma^2(k_i + k_j + 3))}{K^3}$$

$$> (k_i - 1)(k_j - 1) \frac{\gamma^4 + 4b_ib_j(\gamma^2(3(k_i + k_j) + 4k_ik_j + 1))}{K^3} > 0$$

2. $q^N_i > 0$

$$q^N_i = -2b_j(1 - k_i) d^N_i + \frac{\gamma(1 - k_j)}{K} d^N_j + \frac{2b_jm_i - \gamma m_j}{K}$$

$$= -2b_j(1 - k_i) d^N_i + \frac{\gamma(1 - k_j)}{K} d^N_j + K \frac{s_{4i}}{L_i}$$

$$= s_{4i} \left( \frac{K}{L_i} + \frac{(1 - k_i)(1 - k_j)}{K^2(4s_is_j - s_{3i}s_{3j})} \left( \gamma^2 - 4b_ib_j - 4b_ib_jk_j \right) \right)$$

$$+ 2\gamma b_j s_{4j} \left( 1 - k_i \right) \left( 1 - k_j \right)$$

$$\frac{s_{4j}}{K^2(4s_is_j - s_{3i}s_{3j})}$$

where

$$\frac{K}{L_i} + \frac{(1 - k_i)(1 - k_j)}{K^2(4s_is_j - s_{3i}s_{3j})} \left( \gamma^2 - 4b_ib_j - 4b_ib_jk_j \right)$$

$$= 8Kb_ib_j \left( \frac{2b_ib_j(k_j + 1) - \gamma^2}{L_i} \left( \gamma^4 + 4b_ib_j(4b_ib_j(k_j + 1)(k_i + 1) - \gamma^2(k_i + k_j + 3)) \right) \right)$$

$$> 0.$$
References