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Production agreements, sustainability investments, and consumer welfare

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ABSTRACT

Schinkel and Spiegel (2017) finds that allowing sustainability agreements in which firms coordinate their investments in sustainability leads to lower investments and lower output. By contrast, allowing production agreements, in which firms coordinate output yet continue to compete on investments, boosts investments in sustainability and may also benefit consumers. We extend these results to the case where investments affect not only the consumers' willingness to pay, but also marginal cost. We show that sustainability agreements continue to lower investments and output levels, while production agreements increase investments but when they benefit consumers, they are not profitable for firms and will therefore not be formed. This implies that exempting horizontal agreements from the cartel prohibition cannot be relied on to advance sustainability goals and satisfy the competition law requirement that consumers must not be worse off.

1. Introduction

Proponents of "green antitrust" argue that competition policy should take into account the promotion of more sustainable production and consumption, and in particular allow sustainability agreements under the antitrust laws.[1] Essential requirements for an exemption from the European cartel prohibition are that the agreements are necessary to generate the sustainability benefits projected, and that consumers receive a "fair share" of those benefits.[2] In particular, the value of the sustainability improvement to the users of the relevant products must be large enough to compensate them for the higher prices that the agreement may bring about.[3] Whether sustainability agreements should be exempt from cartel law, under what conditions exactly, and how to assess those, is currently widely debated.[4]

Schinkel and Spiegel (2017) contributes to this debate by analyzing the incentives of firms to invest in sustainability when they are allowed to form horizontal agreements regarding their investments in sustainability, or output levels, or both. In a two-stage duopoly setting in which firms invest in sustainability in Stage 1, and choose quantities in Stage 2, sustainability agreements, whereby firms choose investments in sustainability in Stage 1 cooperatively, but then engage in quantity competition in Stage 2, lead to lower sustainability and output levels than when firms compete in both stages. This finding is in stark contrast to the current policy proposals to allow firms to coordinate their sustainability efforts, but not their output levels or prices.[5]

Moreover, Schinkel and Spiegel (2017) shows that production agreements, under which firms choose their investments in sustainability independently, but then coordinate their output levels, lead to higher sustainability than when firms compete in

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1 See Kingston (2011) and Holmes (2020). Schinkel and Treuren (2021b) offers a critical perspective.

2 The conditions are given in Article 101(3) of the Treaty on the Functioning of the European Union, of which all Member States have close equivalents in their national competition laws. The Dutch Authority for Consumers & Markets (ACM) published *Guidelines on Sustainability Agreements* (second draft, 21 January 2021) that detail the exemption requirements.

3 See Badea et al. (2021), page 6.

4 See the European Commission's website on *The European Green Deal and Competition Policy* (https://ec.europa.eu/competition-policy/policy/green-gazette_en) and Chapter 9 *Sustainability Agreements* of the European Commission's draft Guidelines on Horizontal Co-operation Agreements, published for consultation on 1 March 2022 (https://ec.europa.eu/competition-policy/public-consultations/2019-hbers_en).

5 See Badea et al. (2021) and ACM (2021).

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both stages. This result is surprising and suggests that if policy-makers wish to use competition policy as a tool for advancing sustainability goals, they should allow coordination of output levels rather than investment levels. The reason why production agreements can stimulate investments in sustainability is that coordination of output levels in Stage 2 increases the marginal benefit from investment in Stage 1. The beneficial effect of higher sustainability investments may outweigh the negative effect of output restriction and thereby benefit consumers overall.[6]

In this paper, we extend the setting in Schinkel and Spiegel (2017) to the case where investments in sustainability also affect the marginal cost of production. We show that compared to competition in both stages, sustainability agreements continue to lead to lower investments in sustainability and lower output. Although production agreements boost investments in sustainability, they benefit consumers only when the incentives to invest are sufficiently strong, but then firms end up overinvesting in a way that diminishes their profits. The conclusion is that voluntary horizontal agreements between rival firms – whether they involve cooperation on the choice of investments in sustainability or on the choice of output – cannot be relied on to both promote sustainability and also benefit consumers.

2. The setting

The model extends the analysis in Schinkel and Spiegel (2017). Two firms produce differentiated goods and compete in two stages: first they invest in sustainability and then they set quantities. The demand functions for the two goods are derived from the preferences of a representative consumer with a quadratic utility function. The resulting inverse demand functions are linear:

$$p_1 = a + v_1 - q_1 - \gamma q_2, \qquad p_2 = a + v_2 - q_2 - \gamma q_1,$$

where p_1 and p_2 are prices, q_1 and q_2 are quantities, v_1 and v_2 are the sustainability levels of the two goods, which consumers care about, and $a > 0$ and $\gamma \in (0, 1)$ are the intercept of the inverse demand functions and the measure of product differentiation.

When firm $i = 1, 2$ chooses sustainability level v_i, it incurs a fixed cost $\frac{rv_i^2}{2}$, $r > 0$, and its marginal cost of production changes from k (without investments) to $k + (1-\kappa)v_i$, where $0 \leq \kappa \leq \overline{\kappa} \equiv \frac{2\sqrt{2r(1-\gamma)(1-\gamma^2)}}{2-\gamma}$.[7] That is, higher levels of κ are associated with lower marginal costs. Note that the upper bound on κ, $\overline{\kappa}$, falls from $\sqrt{2r}$ when $\gamma = 0$ to 0 when $\gamma = 1$. We assume that $\kappa \geq 0$, because if $\kappa < 0$, investment in sustainability increases marginal cost by more than it increases the willingness of consumers to pay and hence firms will not invest. The assumption that $\kappa \leq \overline{\kappa}$ ensures that firms' reduced-form profits are concave in r. Note that investment in sustainability is marginal cost increasing if $\kappa < 1$, and marginal cost decreasing if $\kappa > 1$; the latter is possible however only if γ is relatively low, otherwise $\overline{\kappa} \leq 1$.

Using $A \equiv a - k$, the profit of firm $i = 1, 2$ is then

$$\pi_i(q_1, q_2, v_1, v_2) = \left(A + \kappa v_i - q_i - \gamma q_j\right) q_i - \frac{rv_i^2}{2}, \tag{1}$$

where the bracketed term on the right-hand side is the price-cost margin of firm i.

Consumer surplus when the representative consumer has a quadratic utility function is given by

$$CS(q_1, q_2) = \frac{q_1^2 + q_2^2 + 2\gamma q_1 q_2}{2}.$$

Under symmetry where $q_1 = q_2 = q$, consumer surplus becomes $CS(q) \equiv CS(q, q) = (1+\gamma)q^2$.

2.1. The competitive benchmark

Consider the case where firms compete in both stages. Noting that the profit of firm i is concave in q_i, the Nash equilibrium in Stage 2 where firms choose their output levels is given by

$$\begin{aligned} q_1^*(v_1, v_2) &= \frac{2(A+\kappa v_1) - \gamma(A+\kappa v_2)}{4-\gamma^2}, \\ q_2^*(v_1, v_2) &= \frac{2(A+\kappa v_2) - \gamma(A+\kappa v_1)}{4-\gamma^2}. \end{aligned} \tag{2}$$

Given (2), the reduced-form profit of firm i is

$$\pi_i^*(v_1, v_2) = \left(q_i^*(v_1, v_2)\right)^2 - \frac{rv_i^2}{2}. \tag{3}$$

The assumption that $\kappa \leq \overline{\kappa}$ ensures that $\pi_i^*(v_1, v_2)$ is concave in v_i.[8]

At Stage 1, the two firms simultaneously choose their sustainability levels to maximize their respective reduced-form profit functions. The resulting Nash-equilibrium sustainability level is

$$v_1^* = v_2^* = v^* = \frac{4A\kappa}{r(2+\gamma)\left(4-\gamma^2\right) - 4\kappa^2}.$$

The assumption that $\kappa \leq \overline{\kappa}$ ensures that $v^* > 0$.[9]

Substituting v^* in (2) and in (3), the Nash equilibrium output of each firm is

$$q^* = \frac{Ar\left(4-\gamma^2\right)}{r(2+\gamma)\left(4-\gamma^2\right) - 4\kappa^2},$$

and its corresponding profit is

$$\pi^* \equiv \pi_i^*\left(v_1^*, v_2^*\right) = \frac{A^2 r\left(r\left(4-\gamma^2\right)^2 - 8\kappa^2\right)}{\left(r(2+\gamma)\left(4-\gamma^2\right) - 4\kappa^2\right)^2}.$$

Note that q^* has the same sign as v^* and is therefore positive. Moreover, $\pi^* > 0$, because as we showed above $\frac{\partial^2 \pi_i^*(v_1,v_2)}{\partial v_i^2} = \frac{8\kappa^2}{(4-\gamma^2)^2} - r < 0$, implying that the numerator of π^* is positive.

2.2. Production agreements

Under a production agreement, firms jointly choose their output levels in Stage 2 to maximize the sum of their profits, but still compete in Stage 1 when they choose their investments in sustainability. The resulting output levels are

$$\begin{aligned} q_1^{pc}(v_1, v_2) &= \frac{A+\kappa v_1 - \gamma(A+\kappa v_2)}{2\left(1-\gamma^2\right)}, \\ q_2^{pc}(v_1, v_2) &= \frac{A+\kappa v_2 - \gamma(A+\kappa v_1)}{2\left(1-\gamma^2\right)}, \end{aligned} \tag{4}$$

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6 Schinkel and Treuren (2021a) shows that when there are more than two firms, a production agreement always harms consumers, because the negative effect of output reduction outweighs the positive effect of higher investment. The paper also considers cooperation among a subset of firms, and firm-side intrinsic motivation for sustainability efforts.

7 In most of Schinkel and Spiegel (2017), marginal cost is assumed to be k, i.e., $\kappa = 1$, and $r \geq 1$. Other than that, the setting here is identical to that in Schinkel and Spiegel (2017).

8 Since $\kappa \leq \overline{\kappa}$, $\frac{\partial^2 \pi_i^*(v_1,v_2)}{\partial v_i^2} = \frac{8\kappa^2}{(4-\gamma^2)^2} - r \leq \frac{8\overline{\kappa}^2}{(4-\gamma^2)^2} - r = \frac{-r\gamma^2\left(\gamma^4 - 4\gamma^3 - 4\gamma^2 - 32\gamma + 48\right)}{(2-\gamma)^4(2+\gamma)^2} < 0$.

9 To see why, note that since $\kappa \leq \overline{\kappa}$, $r(2+\gamma)\left(4-\gamma^2\right) - 4\kappa^2 \geq r(2+\gamma)\left(4-\gamma^2\right) - 4\overline{\kappa}^2 = \frac{r\gamma\left(16(1+\gamma) - 24\gamma^2 + 2\gamma^3 - \gamma^4\right)}{(2-\gamma)^2} > 0$.

where the superscript pc stands for "production cooperation." Substituting in (1), the reduced-form profit of firm i is

$$\pi_i^{pc}(v_1, v_2) = q_i^{pc}(v_1, v_2)\frac{A + \kappa v_i}{2} - \frac{r v_i^2}{2}. \tag{5}$$

The assumption that $\kappa \le \overline{\kappa}$ ensures that $\pi_i^{pc}(v_1, v_2)$ is concave in v_i.[10]

At Stage 1, firms simultaneously and independently choose their sustainability levels to maximize their respective reduced-form profits. The resulting sustainability levels are

$$v_1^{pc} = v_2^{pc} = v^{pc} = \frac{A\kappa(2-\gamma)}{4r\left(1-\gamma^2\right) - \kappa^2(2-\gamma)}.$$

The assumption that $\kappa \le \overline{\kappa}$ ensure that $v^{pc} > 0$.[11]

Substituting v^{pc} in (4) and (5), and using the definition of $\overline{\kappa}$, the output of each firm in a production agreement is

$$q^{pc} = \frac{2Ar(1-\gamma)}{4r\left(1-\gamma^2\right) - \kappa^2(2-\gamma)},$$

resulting in profits

$$\pi^{pc} \equiv \pi_i^{pc}\left(v_1^{pc}, v_2^{pc}\right) = \frac{A^2 r (2-\gamma)^2\left(\overline{\kappa}^2 - \kappa^2\right)}{2\left(4r\left(1-\gamma^2\right) - \kappa^2(2-\gamma)\right)^2}.$$

Note that q^{pc} has the same sign as v^{pc} and is therefore positive. Moreover, $\pi^{pc} > 0$, as $\kappa \le \overline{\kappa}$.

2.3. Sustainability agreements

Under a sustainability agreement, firms jointly choose their sustainability levels, v_1 and v_2, in Stage 1, but then compete in Stage 2 when they choose their production levels. Given that firms compete in Stage 2, the equilibrium output levels in Stage 2 are still given by (2) and the resulting reduced-form profits are still given by (3). At Stage 1, the two firms choose v_1 and v_2 to maximize the sum of their reduced-form profits $\pi_1^*\left(v_1^*, v_2^*\right) + \pi_2^*\left(v_1^*, v_2^*\right)$. The resulting sustainability levels are

$$v_1^{sc} = v_2^{sc} = v^{sc} = \frac{2A\kappa}{r(2+\gamma)^2 - 2\kappa^2},$$

where the superscript sc stands for "sustainability cooperation". The assumption that $\kappa \le \overline{\kappa}$ ensures that $v^{sc} > 0$.[12]

Substituting v^{sc} in (2), the resulting output of each firm is

$$q^{sc} = \frac{Ar(2+\gamma)}{r(2+\gamma)^2 - 2\kappa^2},$$

which is positive because $v^{sc} > 0$.

2.4. Comparison of the three regimes

To compare sustainability levels and consumer surplus under competition in both stages and under horizontal agreements, let $CS^* \equiv CS(q^*)$ be consumer surplus when firms compete in both stages, and define $CS^{pc} \equiv CS(q^{pc})$ and $CS^{sc} \equiv CS(q^{sc})$ similarly for production and sustainability agreements. It is now useful to define $z \equiv \frac{r}{\kappa^2}$; then the results can be stated in terms of only two parameters: γ and z. Since r is the marginal cost of investment and κ captures the marginal effect of investment on the marginal cost of production, z reflects the strength of the incentives to invest in sustainability, with lower values of z being associated with stronger incentives to invest. Also note that since $\kappa \le \overline{\kappa} \equiv \frac{2\sqrt{2r(1-\gamma)\left(1-\gamma^2\right)}}{2-\gamma}$, $z \ge \overline{z}(\gamma) \equiv \frac{(2-\gamma)^2}{8(1-\gamma)\left(1-\gamma^2\right)}$; that is, our assumption on κ implies that the incentive to invest are not too strong. Moreover, let $\widehat{z}(\gamma) \equiv \frac{4-2\gamma+\gamma^2}{2(1-\gamma)\left(4-\gamma^2\right)}$ and note that $\widehat{z}(\gamma)$ is increasing with γ from 1/2 when $\gamma = 0$ to infinity as $\gamma \to 1$. We now establish the following result.

Proposition 1. *Sustainability is highest under a production agreement and lowest under a sustainability agreement: $v^{pc} > v^* > v^{sc}$. As for consumer welfare, $CS^{sc} < CS^*$ for all feasible parameter values. If $\gamma > 0.7486$, then $CS^{pc} < CS^*$ for all $z \ge \overline{z}(\gamma)$; if $\gamma < 0.7486$, then $CS^{pc} < CS^*$ if $z > \widehat{z}(\gamma)$ and $CS^{pc} > CS^*$ if $\overline{z}(\gamma) \le z < \widehat{z}(\gamma)$.*

Proof. First, note that

$$v^* - v^{sc} = \frac{2Ar\kappa\gamma(2+\gamma)^2}{\left(r(2+\gamma)\left(4-\gamma^2\right) - 4\kappa^2\right)\left(r(2+\gamma)^2 - 2\kappa^2\right)} > 0, \tag{6}$$

and

$$v^{pc} - v^* = \frac{Ar\kappa\gamma^2\left(8+\gamma^2\right)}{\left(r(2+\gamma)\left(4-\gamma^2\right) - 4\kappa^2\right)\left(4r\left(1-\gamma^2\right) - \kappa^2(2-\gamma)\right)} > 0, \tag{7}$$

where the inequalities in (6) and (7) follow because, as shown above, the assumption that $\kappa \le \overline{\kappa}$ ensures that both terms in the denominators are positive.

Second, to examine consumer surplus, recall that at a symmetric solution, $CS(q) = (1+\gamma)q^2$. Hence, it is sufficient to compare q^*, q^{pc}, and q^{sc}. Noting that

$$q^* - q^{sc} = \frac{2Ar\gamma\kappa^2(2+\gamma)}{\left(r(2+\gamma)\left(4-\gamma^2\right) - 4\kappa^2\right)\left(r(2+\gamma)^2 - 2\kappa^2\right)} > 0, \tag{8}$$

where as in (6), the denominator of (8) is positive, it follows that $CS^{sc} < CS^*$ for all feasible parameter values.

Next, note that

$$q^{pc} - q^* = \frac{2Ar\gamma\kappa^2(1-\gamma)\left(4-\gamma^2\right)\left(\frac{4-2\gamma+\gamma^2}{2(1-\gamma)\left(4-\gamma^2\right)} - \frac{r}{\kappa^2}\right)}{\left(r(2+\gamma)\left(4-\gamma^2\right) - 4\kappa^2\right)\left(4r\left(1-\gamma^2\right) - \kappa^2(2-\gamma)\right)}. \tag{9}$$

As in (7), the denominator in (9) is positive; recalling that $\gamma \in (0, 1)$, it follows that $q^{pc} - q^*$ and hence $CS^{pc} > CS^*$ if

$$\underbrace{\frac{r}{\kappa^2}}_{z} < \underbrace{\frac{4-2\gamma+\gamma^2}{2(1-\gamma)\left(4-\gamma^2\right)}}_{\widehat{z}(\gamma)}, \tag{10}$$

and $CS^{pc} < CS^*$ if $z < \widehat{z}(\gamma)$ ($CS^{pc} = CS^*$ only in the knife edge case where $z = \widehat{z}(\gamma)$). Now, recall that $z \ge \overline{z}(\gamma) \equiv \frac{(2-\gamma)^2}{8(1-\gamma)\left(1-\gamma^2\right)}$, and note that $\overline{z}(\gamma) > \widehat{z}(\gamma)$ for all $\gamma > 0.7486$ and $\overline{z}(\gamma) < \widehat{z}(\gamma)$ for all $\gamma < 0.7486$. Hence, if $\gamma > 0.7486$, then $z \ge \overline{z}(\gamma) > \widehat{z}(\gamma)$, implying that $CS^{pc} < CS^*$, and if $\gamma < 0.7486$, then $CS^{pc} < CS^*$ if $z > \widehat{z}(\gamma) > \overline{z}(\gamma)$ and $CS^{pc} > CS^*$ for all $\overline{z}(\gamma) \le z < \widehat{z}(\gamma)$. ■

Proposition 1 extends Propositions 1 and 2 in Schinkel and Spiegel (2017) to the case where investments in sustainability affect not only the consumers' willingness to pay, but also marginal cost (i.e., the case where κ is not necessarily equal

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10 Since $\kappa \le \overline{\kappa}$, $\frac{\partial^2 \pi_i^{pc}(v_1,v_2)}{\partial v_i^2} = \frac{\kappa^2}{2(1-\gamma^2)} - r \le \frac{\overline{\kappa}^2}{2(1-\gamma^2)} - r = \frac{-r\gamma^2}{(2-\gamma)^2} < 0$.

11 To see why, note that since $\kappa \le \overline{\kappa}$, $4r\left(1-\gamma^2\right) - \kappa^2(2-\gamma) \ge 4r\left(1-\gamma^2\right) - \overline{\kappa}^2(2-\gamma) = \frac{4r\gamma\left(1-\gamma^2\right)}{2-\gamma} > 0$.

12 To see why, note that since $\kappa \le \overline{\kappa}$, $r(2+\gamma)^2 - 2\kappa^2 \ge r(2+\gamma)^2 - 2\overline{\kappa}^2 = \frac{r\gamma\left(16\left(1-\gamma^2\right)+\gamma\left(8+\gamma^2\right)\right)}{(2-\gamma)^2} > 0$.

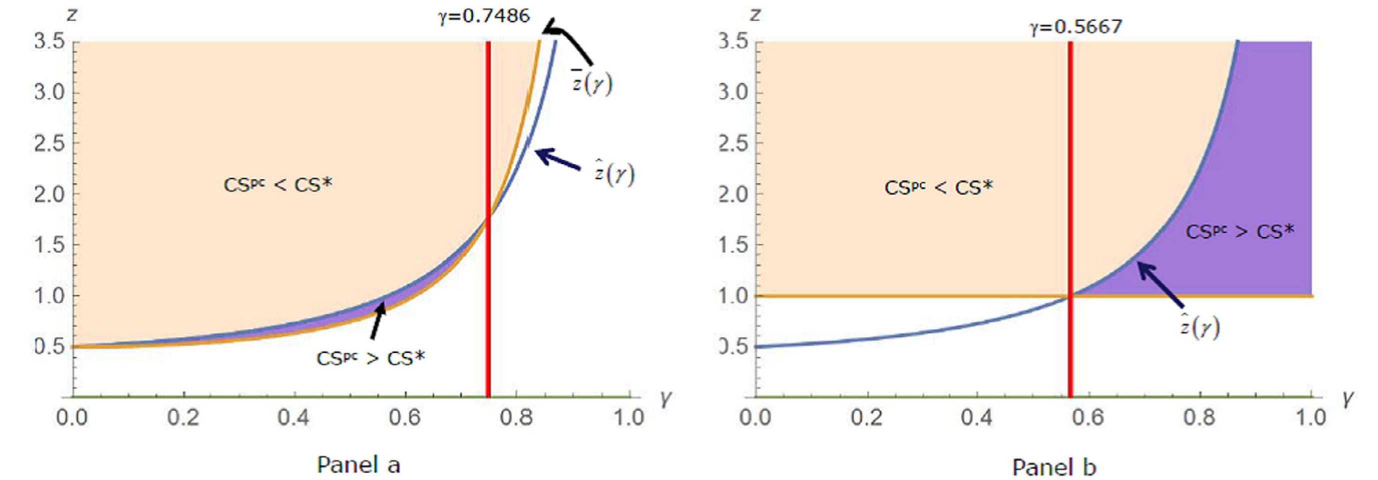

Fig. 1. Consumer surplus in the current paper (Panel a) and in Schinkel and Spiegel (2017) (Panel b).

to 1).[13] It shows that compared to competition in both stages, sustainability agreements lead to lower investments in sustainability and lower consumer surplus, while production agreements lead to higher investments in sustainability. However, whereas in Schinkel and Spiegel (2017), production agreements benefit consumers whenever γ is sufficiently large ($\gamma > 0.5567$), in the present paper they benefit consumers only if γ is sufficiently small ($\gamma < 0.7486$) and when the incentive to invest, as captured by z, is sufficiently strong, i.e., $\overline{z}(\gamma) \leq z < \widehat{z}(\gamma)$.

To understand the difference, note that in both papers, $CS^{pc} > CS^*$ if $z < \widehat{z}(\gamma)$ and $CS^{pc} < CS^*$ if $z > \widehat{z}(\gamma)$. However, while here $z \geq \overline{z}(\gamma)$, in Schinkel and Spiegel (2017), $\kappa = 1$ and $r \geq 1$, so $z \equiv \frac{r}{\kappa^2} \geq 1$. The resulting implications for consumer welfare are illustrated in Fig. 1 in the (γ, z) space. Panel a corresponds to the current paper and Panel b to Schinkel and Spiegel (2017). In both panels, the feasible values of z are represented by the shaded areas. As Panel a shows, in the present paper $z < \widehat{z}(\gamma)$ (in which case $CS^{pc} > CS^*$) only when $\gamma < 0.7486$; when $\gamma > 0.7486$, $\overline{z}(\gamma) > \widehat{z}(\gamma)$, so feasible values of z are above $\widehat{z}(\gamma)$, implying that $CS^{pc} < CS^*$. Panel b shows that in Schinkel and Spiegel (2017), where $z \geq 1$, $z < \widehat{z}(\gamma)$ only when $\gamma > 0.5667$. When $\gamma < 0.5667$, $\widehat{z}(\gamma) < 1$, so feasible values of z are above $\widehat{z}(\gamma)$, so $CS^{pc} < CS^*$.

Proposition 1 is driven by two opposite effects. On the one hand, production agreements boost investments in sustainability because firms cannot individually choose their output levels, so they compete more intensely on investments. The higher investments raise the demand for products and induce firms to expand output. This effect benefits consumers. On the other hand, holding investments fixed, production agreements restrict output and harm consumers. The first, positive, effect dominates the second, negative, effect when z is relatively low because then firms have a strong incentive to invest, so production agreements, which boost investments, are particularly beneficial. This is true however only when the two products are sufficiently differentiated ($\gamma < 0.7486$), otherwise, the incentive to invest cannot be sufficiently high to ensure that the first, positive, effect dominates the second, negative effect. As a result, production agreements harm consumers for all feasible parameter values when the degree of differentiation is relatively low ($\gamma > 0.7486$).

The result that investments in sustainability are larger under a production agreement than under competition in both stages is consistent with Proposition 1 in Fershtman and Gandal (1994) and Proposition 1 in Brod and Shivakumar (1999). Both papers show that firms invest more when they compete in the choice of investment, but subsequently cooperate in the choice of output, a situation referred to as "semicollusion." Intuitively, cooperation in the choice of output increases the marginal benefit from investment and hence induces firms to invest more.[14]

Proposition 1 implies that unlike "green" sustainability agreements, production agreements can simultaneously increase sustainability and consumer surplus, provided that the firms have a sufficiently strong incentive to invest (i.e., z is above the lower bound, $\overline{z}(\gamma)$, but below $\widehat{z}(\gamma)$) and products are sufficiently differentiated ($\gamma < 0.7486$). The next proposition shows, however, that whenever production agreements enhance consumer surplus, they are not profitable for firms.

Proposition 2. *If $CS^{pc} > CS^*$ then $\pi^{pc} < \pi^*$.*

Proof. By Proposition 1, $CS^{pc} > CS^*$ only if $\overline{z}(\gamma) \leq z < \widehat{z}(\gamma)$, which is possible only if $\gamma < 0.7486$. Now,

$$\pi^* - \pi^{pc} = \frac{A^2 r\left(r\left(4-\gamma^2\right)^2 - 8\kappa^2\right)}{\left(r\left(2+\gamma\right)\left(4-\gamma^2\right) - 4\kappa^2\right)^2} - \frac{A^2 r\left(2-\gamma\right)^2\left(\overline{\kappa}^2 - \kappa^2\right)}{2\left(4r\left(1-\gamma^2\right) - \kappa^2\left(2-\gamma\right)\right)^2}$$

$$= \frac{A^2 r}{2}\left[\frac{\frac{r\left(4-\gamma^2\right)^2}{8} - \kappa^2}{\left(\frac{r(2+\gamma)\left(4-\gamma^2\right)}{4} - \kappa^2\right)^2} - \frac{\overline{\kappa}^2 - \kappa^2}{\left(\frac{4r\left(1-\gamma^2\right)}{2-\gamma} - \kappa^2\right)^2}\right] \tag{11}$$

$$= \frac{A^2}{2}\left[\frac{\frac{\left(4-\gamma^2\right)^2}{8} - \frac{1}{z}}{\left(\frac{(2+\gamma)\left(4-\gamma^2\right)}{4} - \frac{1}{z}\right)^2} - \frac{\frac{8(1-\gamma)\left(1-\gamma^2\right)}{(2-\gamma)^2} - \frac{1}{z}}{\left(\frac{4\left(1-\gamma^2\right)}{2-\gamma} - \frac{1}{z}\right)^2}\right],$$

where the last equality follows because $z \equiv \frac{r}{\kappa^2}$ and $\overline{\kappa} = \frac{2\sqrt{2r(1-\gamma)\left(1-\gamma^2\right)}}{2-\gamma}$. It turns out that the square bracketed term in

[13] Indeed, when $\kappa = 1$, investments in sustainability and output levels coincide with those in Schinkel and Spiegel (2017).

[14] Fershtman and Gandal (1994) considers a model with homogeneous products and assumes that firms collude in Stage 2 by dividing the market between them, such that the firms receive in equilibrium equal percentage gains over their profits in the non-collusive equilibrium. Brod and Shivakumar (1999) assumes that products are differentiated, but investments in their model are cost reducing and there are spillovers: the investment of each firm may also lower the cost of the rival firm.

the last line of (11) is strictly positive for all $\gamma < 0.7486$ and all $\bar{z}(\gamma) \leq z < \widehat{z}(\gamma)$.[15] Hence, $\pi^* > \pi^{pc}$ whenever $CS^{pc} > CS^*$. ■

Proposition 2 implies that production agreements which benefit consumers are not profitable for firms and will therefore not be formed voluntarily.[16] To see the intuition, note from Proposition 1 that production agreements benefit consumers when z is not too large, so there are strong incentives to invest. Then, absent a production agreement, profits are relatively high. Holding investments fixed, a production agreement is still profitable as it eliminates competition, but when firms compete on investments, they end up investing more than they would in the competitive benchmark. As a result, their overall profits may decrease below their profits absent a production agreement.

To illustrate, fix $\gamma = 0.5$. Then, $\bar{z}(\gamma) \equiv 0.75$ and $\widehat{z}(\gamma) = 0.866$, so by Proposition 1, $CS^{pc} < CS^*$ if $z > 0.866$ and $CS^{pc} > CS^*$ if $0.75 \leq z < 0.866$. Evaluated at $\gamma = 0.5$, (11) becomes $\pi^* - \pi^{pc} = -\frac{A^2z^2\left(808-2187z+900\kappa^2\right)}{6(32-75z)^2(1-2z)^2}$, which is positive for $z < 1.975$ and negative otherwise. Hence, production agreements are profitable only when $z > 1.975$, but these values of z are above $\widehat{z}(\gamma) = 0.866$, so the agreements do not benefit consumers. Conversely, production agreements benefit consumers when $z < 0.866$, but for these values of z, the agreements are not profitable for firms. Intuitively, production agreements benefit consumers only when the incentive to invest is sufficiently strong (z is relatively low), but then firms end up overinvesting, so their profits drop below their levels absent production agreements.

The result that semicollusion may be unprofitable for firms is consistent with Propositions 2 and 3 in Fershtman and Gandal (1994).[17] However, that paper does not consider the effect of semicollusion on consumers. Our Proposition 2 is also consistent with Brod and Shivakumar (1999), which shows that semicollusion is not profitable for firms when the degree of product differentiation is limited (γ is high) and when spillovers are not too large—see their Figure 2. However, in Brod and Shivakumar (1999) semicollusion can benefit consumers and be profitable for firms, but this occurs only when there are sufficiently large investment spillovers. Absent spillovers, as in our model, production agreements are either not profitable (when γ is high), or are profitable (when γ is low) but reduce consumer surplus.

3. Conclusion

Advocates of green antitrust propose to exempt horizontal agreements from the cartel prohibition if they promote sustainability. A key legal requirement for such an exemption is that consumers receive a high enough share of the benefits from the enhanced sustainability to compensate them for any harm resulting from the agreement, such as possibly having to pay higher prices. We have shown that sustainability agreements lead to lower investments in sustainability and also harm consumers. By contrast, production agreements boost investments in sustainability and may also benefit consumers. However production agreements which benefit consumers are not profitable, so firms will not voluntarily form such agreements. These results imply that permitting horizontal agreements among rival firms cannot simply be relied on to advance sustainability goals and satisfy the legal requirement that consumers must not be worse off.

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[15] The square bracketed term in the last line of (11) turns out to be a ratio of two polynomials: a ninth-degree polynomial of γ which is quadratic in z, and a tenth-degree polynomial of γ which is quartic in z. We therefore resorted to *Mathematica* to determine its sign using the command Reduce[$\pi^* - \pi^{pc}$ <= 0 && $0 < \gamma < 0.7486$ && $\bar{z}(\gamma) \leq z < \widehat{z}(\gamma)$, $\{\gamma, z\}$]. The command returns the output "False", implying that, given the parameter restrictions, $\pi^* - \pi^{pc} > 0$.

[16] Matsui (1989) considers a model in which firms choose capacity in Stage 1 and quantities in Stage 2 and shows that when firms are allowed to collude in Stage 2, consumers may be better off. However, he does not examine whether such an agreement is profitable for firms.

[17] Proposition 2 in Fershtman and Gandal (1994) shows that when investments are cost reducing, semicollusion is not profitable when the cost of investment is relatively low. Proposition 3 shows that this is always the case when investments are in capacity.