When Does Firm Co-operation Foster or Forestall Sustainable Development?

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Abstract

We posit that consumers' preferences for a more or less sustainable variant depend on the perceived social norm, which in turn is shaped by average consumption in the society. We explore the implications of such preferences for firms' price and product competition, focusing on firms' incentives to introduce the more sustainable variant as well as their incentives to co-operate in order to either foster or forestall its introduction. Our main motivation for this is the recent interest of antitrust authorities to potentially exert more leniency towards horizontal agreements motivated by sustainability considerations.

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1 Introduction

Recently, various competition authorities have initiated initiatives and consultations on whether to take a more lenient approach to cooperations, mergers, and restrictions to competition in case these foster sustainability, in particular environmental sustainability. For instance, the European network of competition authorities, including the European Commission's DG Comp, have initiated a taskforce to this aim, and the competition authorities of Greece and the Netherlands have jointly commissioned an expert report on how to measure such sustainability benefits, while the Dutch competition authority has already taken the step to issue draft guidelines.[1] In parallel, a burgeoning law-and-economics literature discusses the potential merit and scope of such initiatives.[2]

In this discussion, it is typically taken as a given that, focussing on environmental sustainability, the institutional environment as a whole falls short of realizing a welfare-maximizing outcome. Absent adequately defined property rights or respective taxes or quota, individual production and consumption decisions fail to internalize all relevant externalities. To sharpen ideas, we focus on the case where production or usage of a particular product of final consumption generate a negative (health) externality on others. Agreements between firms should thus be permitted if they reduce this externality and if the societal benefits from this outweigh the societal loss due to a restriction in competition. If this could be established with only a small margin of error *and* if it is also established with equal certainty that the restriction to competition is necessary to obtain such efficiencies, i.e., that they would not materialize without it, prima facie such an extended test should increase welfare.[3] But such low margins of errors can not be assumed, and with this in mind we need to ask which types of proposals competition authorities may *realistically* face and which types of intended agreements are undertaken if their criteria are extended to include concerns for sustainability.

Taken as a given firms' self-interest in profits,[4] this raises the question of why firms

[1] For the technical report see Inderst et al. (2021) and for the guidelines ACM (2020). Also the Helllenistic authority has issued a statement of principles (HCC 2020).

[2] Much of this literature discusses whether this lies within the existing mandate of competition authorities and, if not, the potential trade-offs of extending their mandate accordingly. To name just three recent contributions, Holmes (2020), Kingston (2019), and van der Zee (2020) all explore the possibilty to extend competition law and its application to embrace sustainability.

[3] Still, it may not be within the current remit of competition law, notably when efficiencies are restricted to consumers within the relevant market; cf. the literature in the preceding footnote and specifically the proposals within the consumer welfare paradigm in Inderst and Thomas (2020).

[4] Throughout this paper we build on this notion. However, we acknowledge that firms may inherit the "gree objectives" of their investors, such as sovereign wealth funds, or of their founder-owners.

would both like to and need to coordinate on sustainable activities, and, likewise, why comparable benefits would not materialize under competition. If (some) consumers put a premium on such sustainable production or consumption, we would trust competition to satisfy this need, rather than cooperation between competitors. And if consumers fail to sufficiently value such features, profit-oriented firms should have no incentives, unless the proposed cooperation is just a means to increase prices and profits.[5]

Advocates of a more lenient approach point to the need to share costs to develop more sustainable products, or to some sort of first-mover disadvantage. Prima facie it is, however, not obvious why this should be specific to such sustainable initiatives. In this paper we offer a rationale that should apply particularly to sustainable initiatives, as it relies on the notion that the introduction and diffusion of more sustainable products change the respective norms in society and thereby individual preferences for the (non-)sustainable variant. Communication between competitors may then facilitate a switch to more sustainable production and consumption. But we also point out when firms would rather want to coordinate not to introduce a more sustainable variant. The latter case is more likely to arise when the considered firms cover most of the relevant market. We find that then the unilateral introduction of a more sustainable variant intensifies competition: Rather than leading to (vertical) differentiation, as market shares affect the social norm and thereby preferences, individual demand becomes more responsive to prices. When the sustainable product allows firms to expand their market, coordination is more likely to result in more sustainable production and consumption. Interestingly, we find that in either case firms' choices of a more sustainable variant represent strategic complements, giving rise to multiple equilibria, but that coordination will lead to the more sustainable outcome only in the latter case. Before returning to implications for antitrust practice, we motivate our key assumption regarding consumer preferences.

For most products, consumers' utility derives from their immediate use benefits. Environmental and resource economics, in particular, acknowledges also so-called non-use benefits or non-use value, e.g., from the knowledge of the existence and preservation of particular species or from animal welfare.[6] Also, when the production or consumption of a product generates externalities on others, to what extent consumers regard or disregard

[5] Such criticism has been advanced (and formalized), for instance, by Schinkel and Spiegel (2017).

[6] More precisely, non-use value refers to a valuation not based on actual, planned, or possible use by oneself (though possibly by others); cf., for instance, Pearce et al. (2006). Such non-use values may still be anthroprocentric, motivated by altruism or bequest motives, or extend beyond, such as in relation to animal welfare.

these consequences of their choices should depend on the prevailing norm. At the core of our model is the presumption that this norm is affected by the anticipated or observed behavior of others. The relevance of how others behave in the same or similar situation has been confirmed repeatedly in the experimental economics literature, notably in games of contributions to a public good, where it has also been associated with notions of fairness and reciprocity.[7] It has also been confirmed by various field studies.[8]

When, as in our model, an individual consumer takes the average behavior of all consumers as the norm, in case of choosing the (cheaper) non-sustainable variant she should perceive a greater disutility the further away this choice is from the norm, i.e., the larger the market penetration or share of the sustainable variant. In the context of environmental economics, such a network effect is most related to Nyborg et al. (2006).[9] We acknowledge that the key relationship between the choice of others and a consumer's individual choice may also have other foundations, such as imitation or learning about the existence of the respective products. In an analysis of optimal taxation, Sartzetakis and Tsigaris (2005) motivate networks effects mainly on the basis of required additional (infrastructure) investment.[10]

In 2015 the Dutch competition authority, ACM, decided on a joint proposal by supermarkets, poultry farmers, and broiler meat processors to produce and sell chicken meat only under enhanced animal welfare standards, the so-called "Chicken-of-Tomorrow" case. To assess this proposal, the ACM conducted a conjoint analysis. There, subjects were confronted with a hypothetical choice situation in which, next to variations in price and several (sustainable) attributes, information was provided on whether a particular option was choice by a small or large number of other consumers. A re-analysis of this data confirms both a sizable effect of the number of other consumers choosing the same option on the respective willingness-to-pay and that this effect is significantly larger with non-

[7] An early contribution by Sugden (1984) assumes that individuals follow a conditional moral rule of "contributing of what I wish others to contribute, but not needing to contribute more than the person who contributes the least". Cf. Bolton and Ockenfels (2000) for a theory of equity and reciprocity. A related, early theoretical analysis is that of Grillo et al. (2001) on price competition with (non-)conformists.

[8] For instance, recycling behavior has been found to strongly correlate with beliefs about recycling in the community; see the various studies quoted in Schultz (2002). Likewise it has been recognized that such a feedback mechanism should be harnessed for policy making. See, for instance, the joint statement on "social norms as solutions" in Science (2016).

[9] Typically, in environmental economics "green preferences" of some consumers are typically taken as exogenously given (e.g., Christantatos et al. 2019).

[10] The Industrial Organization literature analyzes primarily competing networks; cf. Katz and Shapiro (1985) for the seminal contribution. In our subsequent analysis, the algebra for the particular case with asymmetric product choices and no fringe competitors is closely related to Griva and Vettas (2011).

sustainable variants: Subjects seem to be more willing to opt for a cheaper, non-sustainable variant when they believe that this is (still) chosen by a large number of other consumers.[11] The case is also interesting for the following reason. The agreement would have covered virtually the total market. In line with our predictions, firms did not trust that under competition they could raise prices sufficiently to cover both higher marginal costs as well as lump-sum costs of such a change, and consequently they proposed also an agreement to a higher price. The ACM refused to support this agreement, though only after careful deliberation, supported by the aforementioned conjoint analysis.[12]

In our analysis, we restrict consideration solely to coordination by communication, rather than binding agreements (or agreements that are supported by repeated interaction). Consequently, as already noted, communication serves as a way to select among multiple equilibria. This can foster sustainability when firms thereby expect a sufficient expansion of the market, or likewise when this prevents an erosion of the market of the particular product. Otherwise, such coordination is more likely to forestall a change: Then, the fear that a rival may start to produce a more sustainable variant, which under our norm-based preferences would intensify competition, triggers an industry-wide switch to more sustainable production, which firms can prevent by coordinating on the less sustainable status-quo.[13] We note however that in the latter case, in line with the aforementioned "chicken-for-tomorrow" case, firms would prefer a switch to more sustainable production if they were allowed to agree also on a minimum price so as to safeguard their investments in light of subsequent competition. If such agreements are considered by an antitrust authority, they require a detailed (consumer) welfare analysis, as conducted by the ACM in the particular case.

We organize our results as follows. Section 2 introduces the main ingredients of our theoretical analysis. Section 3 analyzes a baseline model. Section 4 extends the analysis. We conclude in Section 5. Proofs are collected in a separate Appendix.

[11] See Inderst et al. (2021).

[12] https://www.acm.nl/en/publications/publication/13761/Industry-wide-arrangements-for-the-so-called-Chicken-of-Tomorrow-restrict-competition

[13] As a case in place, in April 2019 the European Commission sent a Statement of Objections to German premium car manufactures BMW, Daimler, and Volkswagen, covering also brands like Porsche or Audi, accusing the companies of taking part in a collusive scheme, from 2006 to 2014, to limit the development and roll-out of emission cleaning technologies for new diesel and petrol passenger cars sold in the European Economic Area (EEA) (https://ec.europa.eu/commission/presscorner/detail/en/IP_19_2008). Together these companies are supposed cover more than 80 % of the premium market segment.

2 Model and Plan of Analysis

To introduce our key ideas, we keep the market environment as simple as possible. We thus consider a market that operates only for one period, though we discuss below also the additional forces that are at play when introducing dynamics. The market is populated by the mass one of consumers, each of which purchases (at most) a single unit. We focus on a possible agreement by two firms, $i = A$ and B. Firms can produce either a sustainable (s) or a non-sustainable (ns) variant of the product. The non-sustainable variant can be produced also by a market fringe. Firms' offerings are horizontally differentiated, which allows them to earn a margin above costs.

Before we formalize these ingredients, to provide a framework we briefly introduce the model's timing. We suppose that firms A and B choose first whether to offer the more or the less sustainable variant. Later we allow firms at this stage to coordinate their choices. Firms subsequently choose prices. Ultimately consumers make their choices.

2.1 Product Variants and Consumer Preferences

Originally, all firms offer the same variant of the product. We term this the non-sustainable variant (ns). The two strategic firms can offer the sustainable variant (s) after investing $K \geq 0$, which then comes at constant per-unit costs of production $c_s > 0$. K is specific to each firm that switches to the sustainable variant.[14]

A consumer's (gross) utility has three, separable parts: its use value $u_0 > 0$, which we thus suppose to be equal for both variants; the subsequently introduced horizontal preferences for individual firms; and the part that pertains to the product's sustainability feature, as introduced next.

We suppose that production and consumption of a unit of the non-sustainable variant cause damages that are spread equally over the population (of mass one) and that are of size $D > 0$. As each consumer is atomistic, this implies that the damage inflicted on herself by her own consumption is negligible. Consequently, for the subsequently considered consumer choice and market equilibrium, this can be ignored, albeit it provides the basis for referring to the other variant s as sustainable (or socially more desirable) and, consequently, for the formation of a respective social norm, to which we turn now.

Suppose that a given consumer expects $\widehat{S}$ to be the share of consumers that purchase the sustainable variant. Each of these consumers thus reduces damages to society by D,

[14] Otherwise, there is an immediate benefit from an agreement that allows to share such costs.

and the overall expected reduction is $\widehat{S}$ times D. If the considered consumer decides to still purchase the nonsustainable variant, we suppose that this inflicts on her a (psychological) disutility[15] that is increasing in the distance between own behavior and the societal average: $\rho_{ns}\widehat{S}$ with $\rho_{ns} > 0$.[16] For tractability, we thus suppose that the relationship is linear.

We also allow for a possible tax t that may be levied on consumption of the nonsustainable variant. A consumer who purchases the non-sustainable variant at price p thus realizes the utility[17]

$$u_{ns} = u_0 - p - t - \rho_{ns}\widehat{S}, \tag{1}$$

where we have still ignored horizontal firm preferences, as introduced below (as well as the price that needs to be paid).

We turn now to a consumer's utility when purchasing the sustainable variant. We allow $\widehat{S}$ to have also an impact on the utility obtained from the sustainable variant, again linear with slope ρ_s, and that the sustainable variant may also be subsidized by some amount $g \geq 0$. Consumption of the sustainable variant at price p thus realizes the utility

$$u_s = u_0 + g - p + \rho_s\widehat{S}. \tag{2}$$

Denote $\gamma = \rho_{ns} + \rho_s$ and $z = g + t$. In our subsequent analysis these two parameters will be key, and we stipulate for the net effect that $\gamma > 0$.[18] We note again that consumers are not differentiated in their sustainability preferences. We discuss possible implications of such differentiation, together with distributional implications, in our concluding remarks.

2.2 Competition

We achieve tractability by invoking an extended Hotelling model, which will give rise to linear demand. A key element of our comparative analysis is the extent to which

[15] This seemingly relates our formalization of preferences also to the literature of psychological game theory (Geneakoplos et al. 1989, Battigalli and Dufwenberg 2009). There, however, such disutility is experienced in case of "letting down" others, i.e., acting differently from what they expected. Such a feeling of guilt may describe more appropriately a situation with personal interactions (e.g., as in the advisor-experiment performed in Inderst et al. 2019).

[16] We acknowledge that ours represents a rather simplistic way to introduce both the formation of a social norm and individual disutility derived when own behavior falls short of this norm. In particular, we acknowledge that this formalization does not fully comprise and compare the respective contributions, such as the reduction in damages and the payment of a possibly higher price. Incorporating endogenous prices into such a comparison would however make our subsequent analysis intractable.

[17] Recall from the Introduction that the data from the Conjoint Analysis conducted for the "Chicken-of-Tomorrow" case confirmed such a parameter $\rho_{ns} > 0$ (as well as $\gamma > 0$, as introduced below).

[18] This immediately holds when $\rho_s > 0$. We note that the case with $\rho_s < 0$ could arise when the additional utility felt by choosing the sustainable varialbe decreases with the social norm (and thus the extent to which own behavior exceeds the norm).

the introduction of the sustainable variant allows firms to expand their (joint) market, rather than only shifting market shares between them. To analyze this in a tractable way, we introduce three market segments: In market segment A the respective firm A competes with a fringe, firm B competes with a fringe in market segment B, and in market segment C firms A and B compete *against each other*. The respective market sizes (mass of consumers) are denoted by M for the market segment at which firms A and B compete and, assuming symmetry, by m for each of the two fringe market segments, with $\Phi = 2m + M = 1$ (so that $M = 1 - 2m$).

In our baseline model we allow firms A and B to set different prices at the respective market segments. This greatly simplifies the analysis. In the subsequent section we then extend our results to uniform pricing across all market segments. There, we also represent the three market segments as three intervals on a single Hotelling line of length three, with firms A located at 1, firm B located at 2, and fringe market competitors located at 0 and 3, respectively. In our baseline model, only market segment C is modelling in this way, with a standard linear differentiation parameter $\tau > 0$. That is, when purchasing from firm i, a consumer in market segment C with respective (preference) distance x derives utility $u_i - x\tau$, where either $u_i = u_s$ or $u_i = u_{ns}$. In firms' local market segments A and B we suppose that there is at least one fringe firm that is not horizontally differentiated, so that the total demand m in the market segments falls to firm A or B, respectively, if the respective utility is only marginally higher than that of the fringe, and vice versa. We denote prices in market segments A and B with capital letters (p_A and p_B) and prices in market segment C with small letters (p_a and p_b). Note again that in our extension we will impose uniformity ($p_A = p_a$ and $p_B = p_b$).

In what follows, we first analyze, for given parameters, the equilibrium outcome. Based on this we then derive firms' incentives to coordinate, in a way made precise below. Throughout we will ask whether and when firms will choose the sustainable variant. We thereby take it as given that societal benefits are highest when both firms choose the sustainable variant, which holds surely whenever the respective damages $D > 0$ are sufficiently high. We discuss this subsequently, where we also discuss more generally the implications of the chosen consumer preferences for a welfare analysis. We will also discuss the interaction of (dis-)allowing cooperation and a change in $z = g + t$, i.e., the sum of a subsidy and a tax.

In what follows, to restrict attention to interior solutions, we impose the following restriction, where we use $v = z - c_s$:

$$\tau - \gamma > \max(0, v/3). \tag{3}$$

For instance, when $\gamma = 0$ and $v \geq 0$, this requires that horizontal differentiation is, informally speaking, "at-least-as-important" as the marginal net benefit from the sustainable product. We note that we suppress a symmetric requirement that applies when v is sufficiently negative and that ensures a positive market share now for the sustainable product, as this case will never be relevant on the equilibrium path.

3 Pricing Equilibria for the Baseline Model

Recall that in our baseline model, firms can set separate prices in the three considered market segments. These are now considered in turn, always taken as given firms' product choices.[19]

3.1 Equilibrium Prices

Pricing in market segments A and B. Here, given the simple structure of market segments A and B in our baseline model, the respective firm A or B can extract the difference between consumers' willingness-to-pay for its product versus that of the respective fringe. This is zero when the non-sustainable variant is chosen (where we recall that we have normalized costs c_{ns} to zero). Suppose next that firm A offers the sustainable variant. With $\widehat{S}$ denoting consumers' expectations of the actions of all consumers (society), firm A can thus charge the price

$$p_A = u_s - u_{ns} = \gamma\widehat{S} + z.$$

When consumers expect also firm B to offer the sustainable variant, irrespective of how market segment C is divided, we have $\widehat{S} = 1$ and thus $p_A = p_B = \gamma + z$.[20] When only one firm offers the sustainable product, say again A, $\widehat{S}$ depends on consumers' beliefs about how market C is shared between the two firms. As in (a rational expectation) equilibrium expectations must be satisfied, this corresponds to the respective equilibrium market shares in C, to which we turn below.[21] For now we denote the (expected) cutoff

[19] As noted above we suppose that, for reasons of costs or credibility, a firm can not supply different variants to different market segments.

[20] We take as given that both A and B optimally set prices such that they conquer the respective fringe market segment. In our extension, where also the fringe markets have downward sloping demand, this will not necessarily be the case, which will give rise to additional interactions between the prices set by the two firms.

[21] With respect to the formation of expectations, recall that product choice proceeds that of prices.

type in market segment C by $\widehat{x}_C$, which also represents the respective market share of firm A. We briefly summarize results:

Lemma 1 *When firm A offers the nonsustainable variant, in the respective market segment A it can only set a price equal to costs (of zero), and this applies symmetrically to firm B. When both firms offer the sustainable variant, they both set $p_A = p_B = \gamma + z$. When only firm A chooses the sustainable variant, its price in market segment A is $p_A = z + \gamma(m + M\widehat{x}_C)$, while when only firm B chooses the sustainable variant, its price is $p_B = z + \gamma(m + M(1 - \widehat{x}_C))$.*

Pricing in market segment C. When both firms offer the nonsustainable product, pricing in market segment C is standard. Still, for subsequent comparison it is useful to make also this transparent. For this we denote the utility (gross of price and horizontal preferences) by u_i. When interior, the critical (cutoff) consumer in market segment C is then given by

$$x_C = \frac{1}{2\tau}\left[\tau + (u_A - p_a) - (u_B - p_b)\right], \tag{4}$$

which also denotes firm A's share of the respective market. (Recall that we denote prices in market segment C with small subscripts a and b). When both firms offer the nonsustainable variant, so that $u_i = u_{ns}$, this simplifies to

$$x_C = \frac{1}{2\tau}\left[\tau - p_a + p_b\right], \tag{5}$$

so that equilibrium prices are immediately obtained as $p_a = p_b = \tau$ (given costs of zero).

When both firms offer the sustainable variant, recall that then all consumers purchase the sustainable variant (i.e. irrespective of x_C). With this in mind, either firm offers consumers the gross utility $u_s = \rho + z$, so that x_C again simplifies to expression (5). It follows again that firms compete themselves down to a margin (above costs c_s) of τ, $p_a = p_b = c_s + \tau$. For the case where both firms offer the same product variant, we thus have:

Lemma 2 *When both firms offer the nonsustainable variant, in market segment C they set the price $p_a = p_b = \tau$ (given costs of zero). When both offer the sustainable variant, they set $p_a = p_b = c_s + \tau$.*

We turn now to the asymmetric case and suppose for specificity that firm A introduces the sustainable variant. A consumer in market segment C who is at distance x to firm A

thus expects the net utility $u_0 + \rho_s \widehat{S} + g - x\tau - p_a$, while the same consumer expects from firm B the net utility $u_0 - \rho_{ns}\widehat{S} - t - p_b - (1-x)\tau$. The critical type x_C, when interior, thus solves

$$\tau u_0 + \rho_s \widehat{S} + g - x\tau - p_a = u_0 - \rho_{ns}\widehat{S} - t - p_b - (1-x)\tau$$

or

$$x_C = \frac{\tau + z - p_a + p_b + \gamma \widehat{S}}{2\tau}. \tag{6}$$

Importantly, in this expression $\widehat{S}$ depends also on the expected cutoff as now, with asymmetric product choices, $\widehat{S} = m + M\widehat{x}_C$. Substituting and using, from rational expectations, that $\widehat{x}_C = x_C$, we have finally

$$x_C = \frac{1}{2\tau - \gamma M}\left[\tau + z + \gamma m - p_a + p_b\right]. \tag{7}$$

This derivation makes transparent the role of the modified consumer preferences. If firm A reduces its price, this has both a direct effect on the utility of a consumer and an indirect effect as it will expand overall purchases of the sustainable product. This shows up in the (absolute value of the) slope of the cutoff-type: When the price p_a is marginally decreased, ceteris paribus, through a change in x_C the marginal effect on demand in the market segment C (of size M) is $M/(2\tau - \gamma M)$, compared to $M/2\tau$ when both firms choose the same variant (expression (5)). Note that our parameter assumptions imply that $\gamma M < 2\tau$.

Hence, for $\gamma > 0$ demand becomes more responsive to price changes, given the feedback effect that a change in the market share of the sustainable or the non-sustainable product has on consumers' preferences. As we noted in the Introduction, this is akin to a network effect. It intensifies competition, but only so in the asymmetric case where firms have chosen different product variants. Furthermore, for $\gamma > 0$ there is an interaction between the two segments of the market that firm A serves, A and C: As also the mass m of consumers in market segment A choose the sustainable variant, this makes A's product more attractive to all consumers and pushes up x_C. Solving for equilibrium prices, we obtain:

Lemma 3 *When only firm A chooses the sustainable variant, equilibrium prices in market segment C are:*

$$\begin{aligned} p_a &= \tau + \frac{1}{3}\left[2c_s + z + \gamma(m - M)\right], \\ p_b &= \tau + \frac{1}{3}\left[c_s - z - 2\gamma(m + M)\right]. \end{aligned} \tag{8}$$

This gives rise to

$$x_C = \frac{3\tau + z + \gamma(m - M) - c_s}{3\,(2\tau - \gamma M)}. \tag{9}$$

We note that this indeed satisfies $x_C < 1$ if $z - c < 3\tau - \gamma(2M + m)$, which holds by assumption (3).[22] *The case where only firm B chooses the sustainable variant is symmetric.*

The effects of cost differences and of the net direct benefit z for the sustainable product on prices are immediate. More novel is the effect of $\gamma > 0$. The aforementioned increase in the responsiveness of demand to prices unambiguously reduces the price for the non-sustainable product. When market segment C is sufficiently important with $M > m$, also the price of the sustainable product decreases in γ. This follows again from the increased responsiveness of demand. However, when $M < m$, instead, p_a increases in γ. Then the immediate effect of the increased valuation for the sustainable product, which firm A captures by setting a higher price, dominates.[23]

Plugging prices into (7) yields (9) for the equilibrium cutoff in market segment C. When $\gamma = 0$, it is immediate that firm A has a larger share of the market if and only if $z > c_s$: The direct benefits must outweigh the respective cost disadvantage. When $z \geq c_s$, it is likewise intuitive (and straightforward to show) that the market share is higher for all $\gamma > 0$. When however $z < c_s$ and $\gamma > 0$, there are two different forces at work and x_C exceeds one half only if $\gamma > 2\,(c_s - z)$.[24]

3.2 Profits for Given Product Choices

We turn now to equilibrium profits under different product choices. Given symmetry of the two fringe market segments, we can conveniently define such profits as $\pi_{ns,s}$ for the case where the considered firm chooses the nonsustainable variant and the other firm the sustainable variant, and likewise for all other combinations. These profits are gross of investment costs K in case of choosing the sustainable variant. Summing up over all market segments and making use of the characterized equilibrium prices, we obtain first for the symmetric choices the following results:

[22] While also $x_C > 0$ requires parameter restrictions, we suppress these as they are not required for the equilibrium characterization (where product variants are chosen optimally).

[23] As is immediate, we also have that $p_a > p_b$, which follows from higher costs $c_s \geq 0$, from the immediate advantage $z \geq 0$, and from $\gamma > 0$.

[24] Transforming $x_C > 1/2$ yields $\gamma > \frac{c_s - z}{\frac{1}{2}M + m}$, which given $2m + M = 1$ can be written as $\gamma > 2\,(c_s - z)$.

Lemma 4 *Suppose both firms choose the same product variant. If they choose the non-sustainable variant, their gross profits are* $\pi_{ns,ns} = M\frac{\tau}{2}$. *If they choose the sustainable variant, their gross profits are* $\pi_{s,s} = M\frac{\tau}{2} + m(\gamma + z - c_S)$.

From Lemma 4 we have immediately that

$$\pi_{s,s} - \pi_{ns,ns} = m(\gamma + z - c_s). \tag{10}$$

As in market segment C the higher utility of consumers is fully competed away, when *both* firms switch to the sustainable variant, they only make additional profits from market segments A and B, where they compete against the nonsustainable fringe (and only when $\gamma + z - c_s > 0$). Importantly, for the market segment C the fact that also the rival switches to the sustainable variant is beneficial: It allows to extract from each consumer in markets A or B the incremental utility $\gamma + z$, given that, with also the other firm offering the sustainable variant, the market share of the sustainable variant is equal to one. Instead, as we have already observed, when only firm A offers the sustainable variant, for instance, the incremental utility it can extract in market A is only $z + \gamma(m + Mx_C)$, thus lower by $\gamma M(1 - x_C)$. We now turn to this asymmetric case.

Lemma 5 *Suppose only firm A offers the sustainable product variant. Then firms' gross profits are given by*

$$\begin{aligned} \pi_{s,ns} &= m(z + \rho(m + Mx_C) - c_s) + Mx_C \left[\tau + \frac{1}{3}\left[z + \rho(m - M) - c_s\right]\right], \qquad (11) \\ \pi_{ns,s} &= M(1 - x_C)\left[\tau + \frac{1}{3}\left[c_s - z - 2\rho(m + M)\right]\right]. \end{aligned}$$

When only firm B offers the sustainable variant, expressions are symmetric (with x_C *replaced by* $1 - x_C$*).*

It is now interesting to focus on the profit that the two firms extract from market segment C. Substituting x_C and slightly abusing notation, while again focusing on the case where A offers the sustainable variant, we have for the respective gross profits obtained from market segment C alone:

$$\pi_{A,C} = \frac{M\left[3\tau - (c_s - z) + \gamma(m - M)\right]^2}{9\left(2\tau - \gamma M\right)}, \tag{12}$$

$$\pi_{B,C} = \frac{M\left[3\tau + (c_s - z) - \gamma(m + 2M)\right]^2}{9\left(2\tau - \gamma M\right)}. \tag{13}$$

The difference between the two firms' profits is,

$$\pi_{A,C} - \pi_{B,C} = \frac{M}{3}\left[2\left(z - c_s\right) + \gamma(2m + M)\right],$$

which, taking into account $2m + M = 1$, becomes,

$$\pi_{A,C} - \pi_{B,C} = \frac{M}{3}\left[2\left(z - c_s\right) + \gamma\right].$$

Thus,the firm introducing the sustainable variant, firm A, gains higher profits in the contested market C, if $\gamma > 2\left(c_s - z\right)$, which is equivalent to the condition that yields $x_C > 1/2$. As we already observed, this holds when $z \geq c_s$ or when $z < c_s$ and $\gamma > 2\left(c_s - z\right)$.

When there is only market segment C, as $M = 1$, and when there is no direct (dis-)advantage of the sustainable product as $z = c_s$, $\pi_{A,C}$ simplifies to

$$\pi_{A,C} = \frac{M\left(3\tau - \gamma\right)^2}{9\left(2\tau - \gamma\right)},$$

which is strictly decreasing in γ.[25] The reason is that $\gamma > 0$ and a further increase in γ intensify competition, which, when only the market segment C is active, decreases both firms' profits.[26] When we no longer take the corner case with $M = 1$, we find that $\pi_{A,C}$ still decreases with γ as long as market segment C is sufficiently important, but increases with γ when M is sufficiently low.[27] We return to this discussion when comparing profits to determine equilibrium product choice.

4 Analysis of the Baseline Model

It is instructive to first consider two corner cases, with either only market segment C ($M = 1$) or only the two fringe market segments ($M = 0$). This will allow us to isolate the key economic forces, from which a trade-off results for interior values of M.

[25] In fact, we have

$$\frac{d}{d\gamma}\frac{(3\tau - \gamma)^2}{(2\tau - \gamma)} = \frac{2\gamma - 6\tau}{2\tau - \gamma}.$$

Recall now the (interior solution) condition $z - c_s < 3\tau - 4\gamma(M - m)$, which for $z = c_s$ becomes $\gamma < \frac{3}{4}\tau$, which implies that $2\tau - \gamma > 0$ and $2\gamma - 6\tau < 0$.

[26] Of course, when $z > c_s$, then there is still a direct advantage from choosing the sustainable product, without intensifying competition.

[27] When $z = c_s$, we have

$$\frac{d\pi_{A,C}}{d\gamma} = \frac{d}{d\gamma}\frac{\left(3\tau + \gamma(m - M)\right)^2}{(2\tau - \gamma M)} = -\frac{2}{2\tau - M\gamma}\left(M - m\right)\left(3\tau - M\gamma + m\gamma\right),$$

which is now positive when $m - M > 3\tau/\gamma$ or, using $M = 1 - 2m$, $M < 2/3 - \tau/(3\gamma)$.

4.1 Corner Case with $M = 0$

Recall the notation $v = z - c_s$. When we shut down market segment C, where the two firms compete, we have the following result:

Proposition 1 *Take the case where $M = 0$ so that firms A and B do not directly compete. There exist two cutoff levels for the investment costs K, $K'_{M=0} = \frac{1}{2}(\frac{1}{2}\gamma + v)$ and $K''_{M=0} = \frac{1}{2}(\gamma + v)$, so that in a pure-strategy equilibrium, for $K < K'_{M=0}$ both firm choose the sustainable variant, for $K > K''_{M=1}$ both firms choose the nonsustainable variant, while for $K'_{M=0} \leq K \leq K''_{M=0}$ there exists both an equilibrium where both firms choose the sustainable variant and one where no firm does so.*

The fact that

$$K''_{M=0} - K'_{M=0} = \frac{1}{4}\gamma > 0$$

captures the positive externality that the choice of the sustainable product of one firm has on the other firm's demand in its respective local market, when $\gamma > 0$. From the perspective of firm A, when also firm B starts to offer the sustainable variant, this increases all consumers' willingness-to-pay for the sustainable variant as, by raising market penetration, it pushes up the respective social norm. Consequently, firm A can charge a higher price relative to the nonsustainable product offered by the fringe. In this sense, a "second mover" (though recall that we consider a simultaneous-moves game) has higher incentives to also switch to the sustainable variant, compared to a "first mover". Put differently, investments in the sustainable products represent strategic complements. When $K'_{M=0} \leq K \leq K''_{M=0}$ this effect gives rise to a possible coordination failure between the two firms: For this range of values of K firms would benefit from coordination to rule out the (from their perspective) Pareto dominated outcome where none invests in the sustainable variant. We return to this below.

4.2 Corner Case with $M = 1$

We next analyze the corner case when only market segment C exists. Here, we already noted that when $\gamma > 0$, competition intensifies in the presence of asymmetric product choices. For an illustration, take again first the case where $z = c_s$ (and thus $v = 0$), so that there is not an immediate (dis-)advantage from the sustainable variant. While for $\gamma > 0$, a firm with a sustainable variant has a competitive advantage, this is more than outweighed by the profit loss that results from increased competition. Assume now hypothetically that, still with $z = c_s$, one firm would nevertheless be expected to choose the sustainable product. Then, ignoring for now investment costs K, it is strictly profitable that also the other firm follows suit, as this reduces competition, at least when $\gamma > 0$. Again investments in the sustainable products are strategic complements, i.e., the incentives of a "second mover" are strictly higher than that of a "first mover", though the rationale is clearly entirely different from the preceding case with $M = 0$.

And this result no longer holds when $\gamma = 0$. To the contrary, with standard preferences ($\gamma = 0$) and $v > 0$, so that the sustainable product is superior, it is well-known that investments represent strategic substitutes, not complements: Incentives are strictly lower for the "second mover" than for the "first mover".[28] Intuitively, the "first mover" will command over a larger market share over which he can recoup the fixed investment costs. When also the "second mover" invests, gross profits from market segment C alone return only to the previous level, and neither firm will recoup its investment costs.

Summing up, this initial discussion suggests that, next to investment costs K, the equilibrium characterization for $M = 1$ depends crucially on the choice of $v = z - c_s$ and γ, as these parameters determine both whether a switch to sustainability is profitable at all and whether it is more profitable for a "first mover" or a "second mover" (so that choices are either strategic substitutes or complements).

Proposition 2 *Take the case where $M = 1$ so that firms A and B only serve the market segment on which they compete. When $\gamma > 0$, there exists $v' > 0$ so that the following characterizes all pure-strategy equilibria in product choice:*
(1) When $v < v'$: There exist thresholds $0 \leq K'_{M=1} < K''_{M=1}$ such that i) for $K < K'_{M=1}$ both firms choose the sustainable variant, ii) for $K > K''_{M=2}$ no firm chooses the sustainable variant, iii) for $K'_{M=1} \leq K \leq K''_{M=1}$ there exist multiple equilibria where either both or none of the firms choose the sustainable variant;
(2) When $v > v'$: There exist thresholds $0 < K'_{M=1} < K''_{M=1}$ such that i) for $K < K'_{M=1}$ both firms choose the sustainable variant, ii) for $K > K''_{M=1}$ no firm chooses the sustainable variant, iii) for $K'_{M=1} < K < K''_{M=1}$ only one firm chooses the sustainable variant (while thus only for $K = K'_{M=1}$ and $K = K''_{M=1}$ there are multiple equilibria).

Hence, in Case 1, with $v < v'$, firms' choices to invest in the sustainable variant represent strategic complements (as when $M = 0$, albeit for different reasons, as we already

[28] Cf. Athey and Schmutzler (2001).

explained).[29] In Case 2, with $v > v'$, these are instead strategic substitutes. In Case 1 there is thus again scope for coordination so as to select one of the two equilibrium outcomes. Now firms would however want to coordinate on the non-sustainable outcome. This follows immediately as for $M = 1$ firms' gross profits are identical $\pi_{ns,ns}(M = 1) = \pi_{s,s}(M = 1)$, while they need to invest $K > 0$ in the sustainable case. Consumers' higher willingness-to-pay is fully competed away. We next summarize the respective implications for the scope of coordination in the two presently analyzed corner cases ($M = 0$ and $M = 1$).

4.3 Scope for Coordination

We first summarize the preceding observations:

Corollary 1 *When $M = 0$, for $K'_{M=0} \leq K \leq K''_{M=0}$ cooperation that allows firms to coordinate on their mutually preferred equilibrium (among the multiple equilibria) will lead to the sustainable instead of the non-sustainable outcome. When $M = 1$ and $v < v'$ (Case 1), such coordination will instead allow firms to coordinate on the non-sustainable outcome. When $M = 1$ and $v > v'$ (Case 2), coordination has no effect on the outcome.*

In the interest of achieving a more sustainable product choice antitrust authorities should thus allow such coordination when $M = 0$, but not when $M = 1$. We acknowledge that in our presently analyzed corner cases, these stark results may look obvious, as when $M = 0$ the considered firms do not compete in their respective market segment. The key insight is however that both when $M = 0$ and when $M = 1$ firms have strictly positive incentives for such coordination when $\gamma > 0$. When $\gamma = 0$, instead, there is always (generically) a unique equilibrium in pure strategies, so that there is no scope for such cooperation.

We acknowledge that our analysis restricts cooperation to a coordination (in case of multiple equilibria). More far reaching, cooperation would required a binding agreement. When $M = 1$, firms have indeed incentives to cooperate even further in their product choice. This is most immediately seen for all sufficiently low values of K where there exists a unique equilibrium with both firms choosing the sustainable variant ($K < K'_{M=1}$). As noted above, then firms will compete themselves down to gross profits that are identical to those when they both had chosen the non-sustainable variant, $\pi_{ns,ns}(M = 1) = \pi_{s,s}(M = 1)$. In this case they need however a binding agreement (as otherwise either firm would

[29] We note that Case 1 contains two subcases, one where the lower threshold $K'_{M=1}$ is zero, which applies for low values of v, and one where it is strictly positive, which applies for higher values of v.

want to deviate) - or, in a dynamic setting, ways to provide implicit incentives to abstain from the sustainable choice.[30] To make firms prefer the sustainable outcome when $M = 1$, an agreement on prices is necessary (or further subsidies, cf. below), as with the "Chicken-for-Tomorrow" case, which we reviewed in the Introduction.

4.4 Discussion of Other Policy Strategies

We supposed that the policy objective is to ensure that the sustainable variant is chosen by both firms (but that it is not possible to simply oblige firms to make this choice). When $M = 0$, then without coordination, to ensure that this is the case in any equilibrium it must hold that $z \geq 2K - \frac{1}{2}\gamma + c_s$. When there is coordination, it only needs to hold that $z \geq 2K - \gamma + c_s$. Hence, by allowing cooperation the necessary subsidy or tax is strictly lower.

When the fringe market represents foreign imports, it may simply not be possible to tax such imports or to subsidize national sustainable production sufficiently without infringing on trade agreements and WTO-rules or inviting retaliatory actions.[31] Cooperation may then allow to achieve the desired outcome without such an infringement.

When $M = 1$, such considerations may not be of relevance, as all potential suppliers are within the considered market. In case firms could form a binding agreement, however, any size of z would be insufficient: Firms will pass on the respective taxes to consumers when choosing the nonsustainable variants and they are aware that they would compete away the respective subsidies obtained by consumers. When firms can, in this case, form such binding agreements, any such policies are thus in vain when $M = 1$. Preventing such (binding) agreements is thus paramount to have firms react to subsidies and taxes. Even when firms can only loosely cooperate through coordinating on their preferred equilibrium, we observe again that now for low values of v this will make these taxes or subsidies ineffective.

Overall, this short discussion underscores the relevance of appropriately dealing with firms' incentives to coordinate and cooperate even when other instruments such as taxes or subsidies are available.

[30] Schinkel and Spiegel (2017) have analyzed the various cases where, with standard preferences, firms either collude or compete on product choice and/or on the choice of prices (or quantities). When there is subsequent competition on quantities or prices, they also find that firms have high incentives to jointly reduce their investments.

[31] There may also be deadweight losses relating to raising and spending taxes (on subsidies), albeit we note that in the presently analyzed stylized model the respective tax would only be paid off equilibrium as the market is covered by the sustainable product alone.

We finally acknowledge that we have not discussed the possibility to directly subsidize firms' lump-sum investment costs K. This is clearly akin to directly govern firms' actions. Policymakers' limited knowledge about these costs, firms' reduced incentives to invest efficiently in case of such subsidies, as well as deadweight costs associated with raising the respective funds should limit the scope also for this alternative strategy.

4.5 Completing the Baseline Model (Interior M)

We now allow also for interior values of M. To restrict case distinctions in the subsequent proof, we set $v \geq 0$. The previously derived results extend as follows:

Proposition 3 *For general M, the characterization obtained in Propositions 1-2 extends as follows (when $\gamma > 0$ and $v \geq 0$). Again, there exists $v' > 0$ so that for $v < v'$ firms' product choices are strategic complements, implying that for an intermediate interval of values K there exist multiple equilibria (with either none or both firms choosing the sustainable variant). In this case, there exists a threshold $0 < M' < 1$ for the size of the (contested) market segment C, so that firms want to coordinate on the sustainable outcome when $M < M'$ and on the non-sustainable outcome when $M > M'$. When $v > v'$ the (pure-strategy) equilibrium is unique (for generic values of K).*

From this result we can derive some guidance for competition policy. First and foremost, there is a rationale for beneficial cooperation and this is more likely to arise when cooperating firms expect to enlarge the market with the sustainable variant. Then, cooperation is simple coordination on a more sustainable agreement. When no such expansion is possible through the sustainable variant, an introduction is not the preferred outcome of firms, though we showed that without coordination this may materialize. This shows that obviously there can be no policy recommendation of turning a blind eye to firms' communication about their sustainability strategy, hoping that he aforementioned positive selection of equilibria may materialize. In our formal analysis, the obtained threshold M' is decisive for which effect, positive or negative in terms of sustainability, such coordination will have. We recall as well, however, that even for large M the sustainable agreement will always be achieved when firms could cooperate also on (minimum) price. As we discussed already in the Introduction, such a proposed cooperation should require a very detailed analysis by antitrust authorities and clearly there can not be the presumption that firms' preferred price is chosen in consumer interest.

5 Adjusted Model

In our baseline analysis, we sharply distinguished between the competitive segment served by the potentially cooperating firms and the fringe segment, also allowing firms to set different prices on the respective market segments. Our key insights however do not hinge on this, only the obtained greater tractability. In what follows, we thus suppose instead that each firm can set only one price. Also, we no longer assume that demand is degenerate on the fringe segment. More specifically, we now consider an expanded Hotelling model as follows: Along a line of length three, the two strategically acting firms (respectively, their products) are located at 1 (firm A) and 2 (firm B). At each of the two endpoints, 0 and 3, we assume that there is a competitive fringe that supplies the non-sustainable variant at cost. The mass M of consumers is distributed uniformly over the interval $[1, 2]$, the mass m_A over $[0, 1]$ and m_B over $[2, 3]$. Throughout we set again $m_A = m_B = m$ and specify that $2m + M = 1$. Figure 1 illustrates the three market segments:

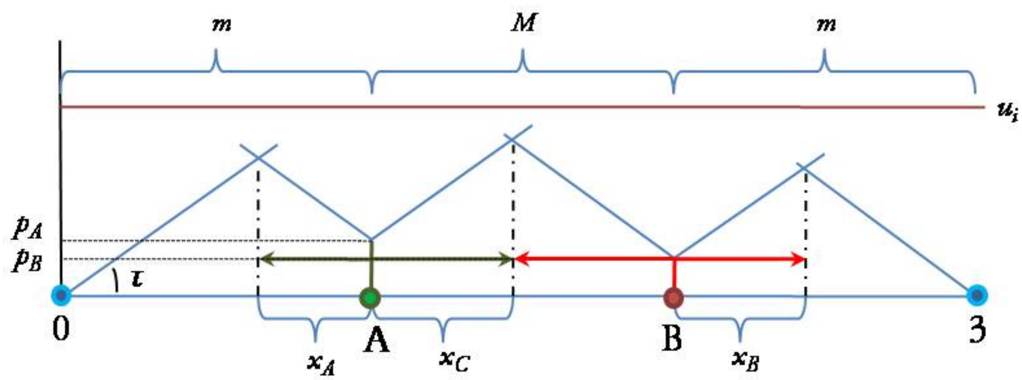

Figure 1: Illustration of the three segments' market

Given the illustration in Figure 1, the quantity sold by firm A is given by $q_A = mx_A + Mx_C$ and that sold by firm B by $q_B = mx_B + M(1 - x_C)$. Now, there is only a single price p_i set by either firm.

5.1 Pricing Equilibrium

We begin with the standard case, where both firms $i = A, B$ choose the nonsustainable variant, so that all offers in the market are homogeneous in this respect. Take first firm A. As the fringe sets the price of the non-sustainable variant equal to its cost (normalized to zero), given firm A's price of p_A, the cut-off type at the segment $[0, 1]$ is given by

$$x_A = \frac{1}{2\tau}(\tau - p_A). \tag{14}$$

Likewise, at the segment $[2, 3]$ we have $x_B = \frac{1}{2\tau}(\tau - p_B)$ for firm B's share. At the segment $[1, 2]$, firm A's share is given by,

$$x_C = \frac{1}{2\tau}(\tau - p_A + p_B),$$

thus, firm B's market share is $1 - x_C$. Therefore, firm i's demand, as a function of its own and firm j's price, $i, j = A, B$ and $i \neq j$, is

$$q_i = mx_i + Mx_c = \frac{m(\tau - p_i) + M(\tau - p_i + p_j)}{2\tau}. \tag{15}$$

Gross profits of firm $i = A, B$ are $\pi_i = q_i(p_i - c_{ns})$ with $c_{ns} = 0$. As long as the respective cutoffs are interior, we can again solve the respective first-order conditions for the unique equilibrium in prices and obtain profits. We postpone a statement of the respective results.

Assume now that both firms A and B offer the sustainable variant. Note that the intermediate market segment is then surely covered by the sustainable product. The coverage of the market segments on either side of it depends on the respective cutoffs. Comparing consumer preferences, as in the baseline model, for the (fringe market) backyard of i we obtain the cut-off

$$x_i(x_j) = \frac{\tau + z + \gamma M + \gamma m x_j - p_i}{2\tau - \gamma m}, \tag{16}$$

where we have already substituted (from rational expectations) the cutoff that is obtained in the other segment, x_j.

This derivation makes again transparent the role of the modified consumer preferences. We comment on this briefly as this could not be observed when demand on the fringe market was degenerate. If a firm reduces its price, this has both a direct effect on the utility of a consumer and an indirect effect as it will expand overall purchases of the sustainable product. This shows up in the (absolute value of the) slope of the cutoff-type: When the price p_i is marginally decreased, ceteris paribus, through a change in x_i the marginal effect on demand from the segment is $m/(2\tau - \gamma m)$, compared to $m/2\tau$ when also firm i would still choose the non-sustainable variant.[32] Furthermore, note the interaction between x_i and x_j: When the (anticipated) market share of the other firm in its

[32]Note again that $\gamma m < 2\tau$ ensures that this positive feedback effect is not too large.

local (or fringe) market segment increases, this pushes up demand for firm i in its local (or fringe) market segment. This shows now up as well when we solve for x_A and x_B jointly, obtaining:

$$x_i = \frac{2\tau(\tau + z + \gamma M - p_i) - \gamma m (p_j - p_i)}{4\tau(\tau - \gamma m)}. \tag{17}$$

Hence, the negative effect of an increase in firm i's own price is reduced (by γm) due to the shift in the norm, and by the same reason firm i's share in its backyard is affected by firm j's price. The symmetric picture arises for x_j. Thus, when considering only the respective backyard market segments, there is a complementarity in firms' offering and pricing of the sustainable variant: As that for firm j becomes more attractive (lower p_j), this also pushes up demand for the sustainable product i in the respective backyard segment. Of course, this is different in the market segment $[1,2]$ that is contested by the two firms. There, the critical cutoff type, when interior and when both offer the same product, satisfies,

$$x_C = \frac{1}{2\tau}(\tau - p_A + p_B). \tag{18}$$

This just replicates the analysis for the preceding baseline model. As the market shares in the contested segment do not affect the total market share of the sustainable product, the responsiveness of demand on this market segment alone is standard (as given by $1/2\tau$). Recall, however, that in the present analysis there is a uniform price p_i for all market segments. Consequently, aggregating over the respective market segments, we have $q_i = mx_i + Mx_c$. Using (17) and (18) the change in firm i's total demand with respect to firm j's price is

$$\frac{dq_i}{dp_j} = \frac{M}{2\tau} - \frac{m^2\gamma}{4\tau(\tau - \gamma m)}.$$

Here, the first expression captures the standard effect from the contested market, where both products are substitutes, while the second expression captures the effect on the backyard market segment. The second effect outweighs the first, so that $\frac{dq_i}{dp_j} < 0$, if, after substituting $m = (1 - M)/2$,

$$M < \frac{1}{3\gamma}\left(-(4\tau - \gamma) + \sqrt{4\tau^2 + \gamma^2 - 2\gamma\tau}\right),$$

which defines a small range of low values of M for $\gamma > 0$ and within the range of admissible values.

We obtain the following characterization for profits, expressed in terms of M, after substituting $m = (1 - M)/2$.

Lemma 6 *Take now the adjusted model. When both firms offer the non-sustainable variant, their profits are*

$$\pi_{ns,ns} = \frac{(1+M)^3}{4(1+3M)^2}\tau. \tag{19}$$

When both offer the sustainable variant, their profits are

$$\pi_{s,s} = \frac{2\Omega\left[(1+M)\tau + (1-M)v\right]^2}{\left[2\tau - (1-M)\gamma\right]\left[8\tau - (1-M)(1+3M)\gamma\right]^2}\tau. \tag{20}$$

where, $\Omega = 4(1+M)\tau - (1-M)(1+3M)\gamma > 0$*.*

We note that when removing costs and benefits of the sustainable variant, that is, $\gamma = c_s = z = 0$, expression (20) reduces comfortably to expression (19). Furthermore, in the absence of backyard markets, $m = 0$, firms earn the same margin τ, regardless of whether they both offer the sustainable or the non-sustainable variant, and thus make profits of $\frac{1}{2}\tau$ (given that then $M = 1$).

We finally consider the case of asymmetric product choices. Here, the key difference with respect to the preceding analysis concerns the contested, intermediate market segment. There, when only firm A offers the sustainable variant, while firm B chooses to offer the non-sustainable variant, the respective cutoff becomes

$$x_C = \frac{\tau + z + \gamma m x_A - p_A + p_B}{2\tau - \gamma M}. \tag{21}$$

Again, this is analogous to the respective expression in the baseline model, and we refer to the discussion there. We derive the following, now asymmetric equilibrium profits. We note that the respective expressions are, however, far more complex in the adjusted model. The subsequent discussion of product choice will therefore only be carried out numerically.

Lemma 7 *When only one firm offers the sustainable variant, equilibrium profits are as follows:*

$$\begin{aligned} \pi_{s,ns} &= \frac{(1+M)\left[(\Phi - M^2\tau)v + (1+M)\Psi\right]^2}{4\left[4\tau - (1+M)\gamma\right]\Phi^2}, \\ \pi_{ns,s} &= \frac{(1+M)^2\Omega X^2}{16\left[4\tau - (1+M)\gamma\right]\Phi^2}\tau. \end{aligned} \tag{22}$$

where, $X = 4(1+2M)\tau - 4Mv - (1+4M+3M^2)\gamma$, $\Phi = 4(1+2M)\tau - (1-M^2)(1+3M)\gamma > 0$, $\Psi = 4(1+2M)\tau - (1+3M)\gamma > 0$ *and* $\Phi - M^2\tau > 0$*.*

Note that we have signed the abbreviated parameters so as to facilitate an immediate comparative analysis. For instance, it is intuitive (and now immediately evident), that $\pi_{s,ns}$ increases in v.

5.2 Product Choice

In discussing firms' choice of product variant, we resort to numerical simulations due to the complexity of the expressions involved. We restrict discussion to the case with $v \geq 0$ and $\gamma > 0$. Recall that for the baseline model Proposition 3 delineates the cases that are of interest for the analysis of the impact of coordination. We now illustrate these cases for the adjusted model.

Recall that coordination plays a role when the following conditions are satisfied: (i) $D_2 - D_1 > 0$, so that product choices are strategic complements and (ii) $D_2 \geq K > 0$, so that the "second mover" indeed has positive incentives. Note that it does not matter whether $D_1 - K$ is positive or negative: From conditions (i) and (ii) there is always an equilibrium where both firms invest. For the corner case with $M = 1$, we know immediately that both firms prefer the no-invest equilibrium, as all potential benefits (from $v > 0$) are competed away, while for $M = 0$ the opposite is true. In Proposition 3 a comparison between the net profits, $\pi_{s,s} - K$ and $\pi_{ns,ns}$, was also immediate and obtained the asserted threshold M'.[33] In the adjusted model, the derivation is again less immediate. We denote the gross difference $D_3 = \pi_{s,s} - \pi_{ns,ns}$, so that when $D_3 > K$ firms would like to coordinate on the sustainable equilibrium while when $D_3 < K$ the opposite holds.

Figure 2 now depicts a numerical example where such a threshold for M arises again. All curves in Figure 2 are drawn for $\tau = 1$, $\gamma = 1/2$, and $v = 0.75$, values that respect assumption (3).

It is evident that for $M = 0$, $D_3 = D_2$, since $D_3 = \pi_{s,s} - \pi_{ns,ns}$, $D_2 = \pi_{s,s} - \pi_{ns,s}$, and obviously $\pi_{ns,ns} = \pi_{ns,s}$ without a competitive segment (as is evident from (22)). We note that D_2 increases,so that the "second mover" incremental profit increases as the competitive segment becomes more important. This is due to the described effect, whereby generating symmetry (by also switching to the sustainable variant) reduces competition (by reducing the responsiveness of demand to price setting). Also $D_2 - D_1 > 0$, so that we can choose a value K that satisfies both conditions i) and ii). We have set $K = 0.15$ in Figure 2, and we see that this generates the cutoff M' so that $D_3 - K$ is indeed positive for lower values and negative for higher values of K. This replicates the finding for the baseline model, and we refer to the respective rationale provided there.

What is now however interesting is that D_3 becomes non-monotonic for relatively low

[33] As is immediate from the profit expressions and as noted in the proof, the threshold is simply $M' = 1 - 2\frac{K}{v+\gamma}$ (when interior).

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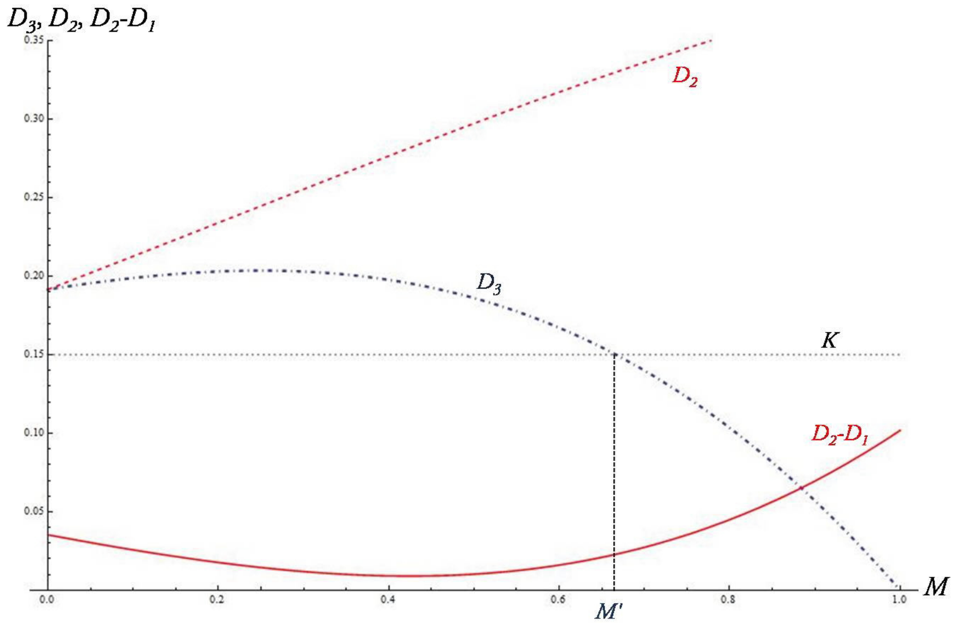

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Figure 2: Incentives for coordination as the size of the contested market changes

values of M. Starting from $M = 0$, as M increases the benefits from a (coordinated) joint switch to the sustainable variant first increase, before they decrease (down to $D_3 = 0$). This is due to the assumption of uniform pricing across all market segments that a firm serves, in difference to separate pricing in the baseline model. The higher price that the sustainable product commands on the "fringes" essentially mitigates price competition on the contested interval. We admit that this somewhat complicates our simple cutoff-rule rule for M , but we note that, as in the baseline model, coordination is always to the non-sustainable outcome for high enough M.

6 Concluding Remarks

The present analysis is motivated by various initiatives and a broadening scholarly dispute on whether and how to integrate sustainability considerations into competition analysis. As noted in the Introduction, much of this dispute is about whether sustainability should represent an objective on its own, so that, for instance, a reduction of externalities on notably non-consumers would become part of the assessment of a merger or horizontal agreement, provided it proves specific. As we noted in the Introduction, such externalities, which should arise almost exclusively with environmental sustainability, are not the focus of our analysis. Here, we take a broader perspective on sustainability, as is also done in the consultations and reports cited in the Introduction, and essentially focus on the importance of the non-use value that consumers may derive when consuming products that, for instance, involve more or less harm inflicted on the environment, on animals, or on workers involved along the value chain. Our key presumption is that this value depends on the perceived social norm and that the latter depends on a consumer's perception of the behavior of others. This norm effect is the basis of our analysis. Applying the most simple competition framework and focusing on cooperation only through coordination, we ask whether such cooperation is then likely to lead to a more sustainable outcome.

We unearthed to main effects. The first effect provides a positive response to the question of whether issues of sustainability, when framed in this way (through a norm effect), may warrant a more lenient approach. The norm effect can turns firms' choices of more sustainable products into strategic complements, as by lifting the norm, a more sustainable offer of another firm relatively increases consumer WTP for such an offer also at all other firms. Firms may then want to coordinate to jointly offer the more sustainable variant. The second effect also involves a strategic complementarity, but it induces firms to instead coordinate on the less sustainable variant. The reason is that when strategic choices of the involved firms essentially determine how a market of fixed size is shared, then, again through the norm effect, a more sustainable choice by one firm intensifies competition and will trigger a sustainable choice also by other firms, though firms would jointly be better off by coordinating on the equilibrium where no firm makes the sustainable choice. Taken together, when the considered norm effect is relevant, it would simply be wrong to blindly take a more lenient approach to firms' communication about their sustainability strategy: A priori it may be equally likely that this forestalls a more sustainable development. That said, however, we do provide a rationale for why sustainability agreements may warrant a particular attention, namely when the positive network effect through the norm is sufficiently strong. In terms of practical relevance, the European Commission could consider this to be still within the scope of the guidelines on horizontal cooperation.

Throughout our analysis we have steered clear of an actual welfare comparison, as we supposed that the objective was to induce more sustainable production. This could be warranted when such an objective was deemed to be part of the remit of a competition authority. Also, our results on the effects of coordination as positive implications are clearly valid regardless of the overall welfare assessment. When consumer surplus was, however, the guiding principle, a welfare analysis would be required. We acknowledge that this raises difficult issues that we have chosen to avoid in our analysis. More precisely, for our analysis of the competitive equilibria, with and without coordination, only the parameter γ was relevant, which captures the change in consumers' incremental WTP for the more sustainable product as the market share of the more sustainable product increases. For a welfare analysis, however, the level of consumer utility is relevant. In particular, when no consumer contributes to a more sustainable development, there is also no discounting of the respective utility from such a product (as represented by $\rho_{ns} > 0$). And when more other consumers purchase a sustainable variant, the individual utility from doing so may decrease (when $\rho_s < 0$), as already discussed. When a permitted competitive restraint changes the social norm and thereby individual WTP from a more or less sustainable variant, calculation of factual and counterfactual consumer welfare requires detailed knowledge of the respective parameters. And it also requires to take a stance on how different utilities derived from the same product under a different (norm) context should be compared. We acknowledge these deeper problems and hope that this contribution stimulates future research and discussion.

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8 Appendix: Proofs

Proof of Proposition 1. Using symmetry, we have for $M = 1$

$$\begin{aligned} \pi_{ns,ns}(M &= 0) = \pi_{ns,s}(M = 0) = 0, \\ \pi_{s,s}(M &= 0) = \frac{1}{2}(\gamma + v), \\ \pi_{s,ns}(M &= 0) = \frac{1}{2}(\frac{1}{2}\gamma + v). \end{aligned}$$

The respective thresholds follow then immediately from

$$\begin{aligned} K'_{M=0} &= \pi_{s,ns}(M = 0) - \pi_{ns,ns}(M = 0), \\ K''_{M=0} &= \pi_{s,s}(M = 0) - \pi_{ns,s}(M = 0). \end{aligned}$$

Q.E.D.

Proof of Proposition 2. Observe first for the two symmetric choices that

$$\pi_{ns,ns}(M = 1) = \pi_{s,s}(M = 1) = \frac{\tau}{2}.$$

For the asymmetric case we have with $M = 1$ that

$$\pi_{s,ns}(M = 1) = \frac{(3\tau + v - \gamma)^2}{9\,(2\tau - \gamma)}$$

and that

$$\pi_{ns,s}(M = 1) = \frac{(3\tau - v - 2\gamma)^2}{9\,(2\tau - \gamma)}.$$

We first discuss the incremental profit (gross of K) for a firm that alone chooses the sustainable variant ("first mover"):

$$\pi_{s,ns}(M = 1) - \pi_{ns,ns}(M = 1) = \frac{(3\tau + v - \gamma)^2}{9\,(2\tau - \gamma)} - \frac{\tau}{2} = \frac{2\,(v - \gamma)^2 + 3\,(4v - \gamma)\,\tau}{18\,(2\tau - \gamma)} =: D_1.$$

This is strictly increasing in v, since $\frac{\partial D_1}{\partial v} = \frac{2(3\tau+v-\gamma)}{9(2\tau-\gamma)} > 0$. Next, $D_1(v = 0) = \gamma\frac{2\gamma-3\tau}{18(2\tau-\gamma)}$, which is strictly negative from (3). Define now the unique value $D_1(v_0) = 0$.

Next, the incremental profit for the "second mover" is

$$\pi_{s,s}(M = 1) - \pi_{ns,s}(M = 1) = \frac{\tau}{2} - \frac{(3\tau - v - 2\gamma)^2}{9\,(2\tau - \gamma)} = \frac{3\,(4v + 5\gamma)\,\tau - 2\,(v + 2\gamma)^2}{18\,(2\tau - \gamma)} =: D_2,$$

where now

$$\frac{\partial D_2}{\partial v} = \frac{2\,(3\tau - v - 2\gamma)}{9\,(2\tau - \gamma)} > 0.$$

Hence, D_2 is increasing in v iff $3\tau > v + 2\gamma$, which holds by (3). Note now that

$$D_2(v = 0) = \frac{\gamma\,(15\tau - 8\gamma)}{18\,(2\tau - \gamma)},$$

which from (3) is strictly positive, so that $D_2 > 0$ for all parameter values.

It is now instructive to first consider the case where $v < v_0$, so that $D_1(v) < 0$. Then for all K there exists an equilibrium where no firm chooses the sustainable product. Define now, for these values of v, $K''_{M=1} = D_2(v) > 0$. When $K > K''_{M=1}$, also a "second mover" is strictly worse off when choosing the sustainable variant, so that the equilibrium with only nonsustainable choices is unique. When $K \leq K''_{M=1}$, however, we know that $D_2(v) - K \geq 0$, so a firm has (weak) incentives to choose the sustainable variant when it anticipates the rival to do so. For $K \leq K'_{M=1}$ there thus exists also an equilibrium where both firms choose the sustainable variant. We set in addition $K'_{M=1} = 0$ when $v < v_0$.

Observe next that

$$D_2 - D_1 = \frac{\gamma\,(9\tau - 5\gamma) - 2v\,(v + \gamma)}{9\,(2\tau - \gamma)}.$$

As discussed in the main text, for $\gamma = 0$, $D_2 < D_1$. When $v = 0$ but $\gamma > 0$, using (3), the converse holds strictly with $D_2 > D_1$, as also discussed in the main text. As $D_2 - D_1$ strictly decreases in v, since $\frac{\partial(D_2 - D_1)}{\partial v} = -\frac{4v+2\gamma}{9(2\tau-\gamma)} < 0$, and as at $v = v_0$ we know $D_1 = 0$ and $D_2 > 0$, so $D_2 - D_1 > 0$, we can define a value $v' > v_0$ where $D_2(v') - D_1(v') = 0$ (provided that this exists while still satisfying (3), which, for given τ and γ, imposes an upper boundary on v). Hence, up to $v < v'$ the incentives of the "second mover" are still strictly higher. The preceding characterization for $v < 0$ now fully extends up to $v < v'$ by using, in addition, $K'_{M=1} = D_1(v)$ when positive.

When $v > v'$, the "first mover" incentives are strictly higher, $D_2 < D_1$. Setting now $K'_{M=1} = D_2(v)$ and $K''_{M=1} = D_1(v)$, we obtain the characterization for Case 2. **Q.E.D.**

Proof of Proposition 3. For general M, profits are given as

$$\begin{aligned}
\pi_{ns,ns} &= M\frac{\tau}{2}, \\
\pi_{s,s} &= M\frac{\tau}{2} + m(\gamma + v), \\
\pi_{s,ns} &= m(v + \rho(m + Mx_C)) + Mx_C\left[\tau + \frac{1}{3}\left[v + \rho(m - M)\right]\right], \\
\pi_{ns,s} &= M(1 - x_C)\left[\tau - \frac{1}{3}\left[v + 2\rho(m + M)\right]\right].
\end{aligned}$$

Substituting x_C and $m = (1-M)/2$ yields for the asymmetric case

$$\pi_{s,ns} = \frac{4v\left[M\left(v-2\gamma\right)+3\tau\left(3-M\right)\right]+\gamma M\left(9\gamma M^2-5\gamma-6\tau-3\gamma M\tau\right)+18\left(\gamma+2M\tau\right)}{36\left(2\tau-\gamma M\right)},$$
$$\pi_{ns,s} = \frac{M\left(2v+\gamma+3M\gamma-6\tau\right)^2}{36\left(2\tau-\gamma M\right)}$$

and thus, again with $D_1 \equiv \pi_{s,ns} - \pi_{ns,ns}$ and $D_2 = \pi_{s,s} - \pi_{ns,s}$,

$$D_2 - D_1 = \frac{Mv\left(3\gamma M-7\gamma-4v\right)+\gamma M\left(6\gamma M-7\gamma-9\gamma M^2\right)+9\gamma M\left(1-M\right)\tau+9\gamma\tau}{36\left(2\tau-\gamma M\right)}.$$

Note that

$$\frac{\partial\left(D_2-D_1\right)}{\partial v} = -\frac{M\left(8v+7\gamma-3\gamma M\right)}{18\left(2\tau-\gamma M\right)},$$

which is surely strictly negative when $v \geq 0$ and $\gamma > 0$. We note again that $D_1 = D_2 = 0$ at $v = 0$ and $\gamma = 0$, while $D_2 - D_1 > 0$ when $v = 0$ and $\gamma > 0$. Taken together, this implies again a unique cutoff value $v' > 0$, where $D_2(v') = D_1(v')$. By the argument in the proof of Proposition 2 we thus have no multiple equilibria when $v < v'$. When $v < v'$, instead, multiple equilibria exist for an intermediate (positive) range of values K when $D_2 > 0$, which holds for $v < v'$.

Regarding which equilibria firms prefer, we need to compare net profits, i.e., $\pi_{s,s} - K$ and $\pi_{ns,ns}$, which obtains a cutoff m' given by $m' = \frac{K}{v+\gamma}$ and from this a cutoff $M' = 1-2m'$ (when interior). **Q.E.D.**

Proof of Lemma 6. Take first the case where both firms choose the non-sustainable variant. The first-order condition for firm i's profit maximization problem yields the price reaction functions

$$p_i = \frac{\left(M+m_i\right)\tau+Mp_j}{2\left(M+m\right)}.$$

Reaction functions are uniquely solved, using symmetry and after substituting $m = (1-M)/2$, as

$$p^* = \frac{\left(1+M\right)\tau}{2}.$$

Substituting p^* yields firm equilibrium demand'

$$q^* = \frac{\left(1+M\right)^2}{8}. \tag{23}$$

Given zero costs, profits are $\pi_{ns,ns} = p^*q^*$, which becomes expression (19).

For the case where both firms offer the sustainable variant, we can proceed likewise to obtain for the symmetric equilibrium price

$$p^* = \frac{4\tau\left[(1+M)\tau + (1-M)z\right] + \Omega c_s}{8\tau - (1-M)(1+3M)\gamma}$$

and for the respective quantity

$$q^* = \frac{\Omega\left[(1+M)\tau + (1-M)v\right]}{2\left[\tau - (1-M)\gamma\right]\left[8\tau - (1-M)(1+3M)\gamma\right]}.$$

where, $\Omega = 4(1+M)\tau - (1-M)(1+3M)\gamma > 0$. With $\pi_{s,s} = q^*(p^* - c_s)$ we finally obtain expression (20). **Q.E.D.**

Proof of Lemma 7. We consider the case where only firm A offers the sustainable variant. The case where only firm B offers this variant is symmetric. To derive the marginal consumer of the sustainable variant in the two market segments $[0,1]$ and $[1,2]$ as a function of prices, we use

$$x_A = \frac{2\tau(\tau + z - p_A) + \gamma M p_B}{2\tau(2\tau - (m+M)\gamma)}, \; x_C = \frac{2\tau(\tau + z - p_A) + (2\tau - \gamma m)p_B}{2\tau(2\tau - (m+M)\gamma)}.$$

Substituting the above into $q_A = m x_A + M x_C$ we derive firm A's total demand, which after substituting $m = (1-M)/2$, is,

$$q_A = \frac{(1+M)(\tau + z - p_A) + 2Mp_B}{4\tau - (1+M)\gamma} \tag{24}$$

and from maximization of $(p_A - c_s)q_A$ its the price reaction function,

$$p_A = \frac{(1+M)(\tau + z + c_s) + 2Mp_B}{2(1+M)}.$$

Firm B captures a segment $x_B = \frac{\tau - p_B}{2\tau}$ of its backyard market and $(1 - x_C)$ of the contested market, and thus its total demand is, $q_B = m x_B + M x_C$, which after substituting $m = (1-M)/2$, yields,

$$q_B = \frac{8M\tau(p_A - z) - \Omega p_B + \tau\left[4(1+M)\tau - (1+4M+3M^2)\gamma\right]}{4\tau\left[4\tau - (1+M)\gamma\right]}.$$

The first-order condition for $p_B q_B$, given that the marginal cost of the non-sustainable variant is zero, yields the price reaction function,

$$p_B = \frac{\left[4\tau - \gamma + 8M(p_A - z) + 4M\tau - (4+3M)\gamma\right]\tau}{4\Omega}.$$

Solving firms' reaction functions yields equilibrium prices,

$$
\begin{aligned}
p_A^* &= \frac{(1+M)\Omega\,(c_s+z) - 8M^2\tau z + (1+M)\Psi\tau}{2\Phi}, \\
p_B^* &= \frac{(1+M)X\tau}{2\Phi},
\end{aligned}
$$

as well as quantities,

$$
\begin{aligned}
q_A^* &= \frac{(1+M)\left[(1+M)\Omega\,(v+\tau) - 8M^2 v\tau\right]}{2\left[4\tau-(1+M)\gamma\right]\Phi}, \\
q_B^* &= \frac{(1+M)\Psi X}{8\left[4\tau-(1+M)\gamma\right]\Phi}.
\end{aligned}
$$

where, $X = 4\,(1+2M)\,\tau - 4Mv - (1+4M+3M^2)\,\gamma$, $\Phi = 4\,(1+2M)\,\tau - (1-M^2)\,(1+3M)\,\gamma > 0$, $\Psi = 4\,(1+2M)\,\tau - (1+3M)\,\gamma > 0$. Substituting back into $(p_A - c_s)q_A$ and $p_B q_B$ yields the respective expressions for $\pi_{s,ns}$ and $\pi_{ns,s}$. **Q.E.D.**