The Ambiguous Effects of Upstream Cartels on Downstream Parties

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Abstract

We investigate cartel damages in a vertically structured market assuming that an upstream cartel with partial market coverage has formed and that products differ in their price-quality pair. We show that cartel outsiders best respond to the cartel conduct by increasing both the price and the quality level of the product. Then, some customers may benefit from the cartel agreement: the positive quality effect may outweigh the negative price effect. We also discuss the specifics of quantifying damages, especially in light of the growing awareness of class actions and compensation for umbrella effects.

Keywords: cartel damages; class action; umbrella effects; vertical product differentiation; vertically structured markets

JEL codes: L40; L41; D21; K21

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1. Introduction

Numerous vertically structured markets have been affected by cartel agreements between upstream suppliers, for example, the market for automotive intermediates (the European Commission has imposed fines of over €2 billion on auto parts cartels since 2013) or the market for convenience goods (e.g., the US "canned tuna cartel" or the European "detergent cartel"). After these cartels were uncovered, private damage suits were filed.

Important insights have already been obtained on how upstream cartels affect direct and indirect parties (i.e., downstream firms and final customers), such as to what extend the pass-on effect reduces a direct customers harm or how the aggregated harm is allocated to injured parties (see, e.g., Verboven and van Dijk 2009, Basso and Ross 2010 and Boone and Müller 2012). However, these studies do not address how cartel outsiders' *best responses* to the cartel price affect harm to injured parties, nor do they discuss how competition in more than one product characteristic affects the market outcome. In this paper, we focus on the latter two issues, because some cartels were not industry-wide: only producers of high-quality products coordinated their strategies, while (vertically differentiated) low-quality products were sold competitively, as, e.g., in the German coffee roasters' cartel (see Hasnas and Wey 2015).

Given this, we assume that products are vertically differentiated, i.e., they differ in their perceived quality level, and that only a partial cartel has formed that includes all producers of high quality products. We then derive the market equilibrium when cartel members increase prices while holding the quality level fixed.[1] The profit maximizing strategy of a cartel outsider then is to raise not only its price but also the quality level of the offered low-quality product: *umbrella effects* occur. In discussing umbrella effects, the literature has so far focused on adjustments in profit-maximizing quantity or price choices (see, e.g., Inderst et al. 2014, Holler and Schinkel 2017, Blair and Durrance 2018 and Napel and Welter 2022). In these constellations, it is usually the case that final customers who have purchased a product produced by a cartel outsider

[1] Almost all cartels uncovered to date have been fined for fixing parameters that directly affect the market price (e.g., list price, offered quantity). That other product characteristics are also relevant to the discussion of the harmfulness of cartels (or mergers) is receiving increasing attention both in theory (see, e.g., Valletti and Zenger 2021 or Johnson and Rhodes 2021) and in practice (e.g., in the European "car emission cartel").

are also harmed since all prices rise. In the model presented here, the umbrella effect on final consumers is ambiguous and depends on their willingness to pay for quality. In particular, some final consumers with low willingness to pay for quality will stop buying the low-quality product, while customers with a medium willingness to pay for quality may even benefit from the cartel agreement.[2]

We then discuss the complexity of quantifying damages by injured parties once the cartel has been uncovered.[3] In order to adequately compensate customers in the EU, three legal aspects are of particular importance in the introduced market environment. First, the *Damages Directive* (Directive 2014/104/EU) stipulates that all injured parties may not only recover overcharge damages, but may also sue for "*. . . gain of which that person has been deprived*" (*restitutio ad integrum*).[4] Second, the European Court of Justice has ruled that proven umbrella losses must also be compensated (see, e.g., CJEU in Kone AG v ÖBB-Infrastruktur AG, 2014). Third, there is an intense debate about how policymakers can adapt legal norms for class action to ensure compensation for end users even in markets where individual damages are small but total harm can be enormous (see, e.g., Uzelac and Voet 2021 and Gaudin and Weber 2021 for an overview and critical discussion).[5]

We argue that quantifying overcharge damages for retailers that sold (customers that bought) the branded product can follow the standard approach in legal practice: compare the actually price paid with the estimated but-for price and taking into account the pass on effect. As far as the deprived gain is concerned, this conclusion is not correct, as its quantification depends on the umbrella effect and is therefore complex. For example, the downstream firm's price-cost margin for selling the low-

[2]In Fershtman and Pakes (2000), (some) customers benefit from increasing quality levels when a cartel is formed. However, the mechanism that leads to this outcome (i.e., *dynamic* incentives to launch products) and the group of customers that benefits (i.e., either all customers or assuming the customers differ in their income, only high-income customers) are different. See Bos and Pot (2012) for an examination of the possibility of welfare-enhancing hard core cartels.

[3]Private antitrust enforcement is well established in the United States (US) and is receiving increasing attention in the European Union (EU) following the adoption of Directive 2014/104/EU, which lowered the legal and economic barriers for harmed parties to sue.

[4]So far, the deprived gain is rarely compensated (see, e.g., Argenton et al. 2020, recital 6.131 or Weber 2021).

[5]In the US, only direct parties, that is, the firm at the next stage of production in a vertically structured market, can recover the overcharge damage. However, to promote deterrence and to capture additional losses due to the deprived gain, the claimant may seek treble damages.

quality product increases for customers who have already purchased this product in the competitive market environment, but it decreases for customers who have substituted the high-quality product in favor of the low-quality product. Similarly, only a structured model may be suitable for finding that some final customers may have benefited from the cartel agreement, while other – who bought the identical product – may have suffered harm.[6]

The structure of the paper is as follows. In Section 2, we introduce the model and deduce the market equilibrium when upstream firms compete or collude. We then derive the harm to the injured parties in Section 3, and discuss the specificities of their compensation in Section 4. We conclude in Section 5.

2. Model

For illustrative purposes, we focus on convenience products in the further analysis. The results are transferable to similarly structured markets.

2.1. General Setup

We consider a market consisting of three levels: the upstream manufacturers, the (downstream) retailers and the final customers. It is assumed that each retailer offers a range of (high-quality) branded products and a single (low-quality) private label product.[7] He sources the branded products from upstream firms, while the private label product is produced in-house.[8]

The quality-price vector (q_j^i, p_j^i) perfectly describes the product of *high* ($j = h$) and the product of *low* ($j = l$) quality with $i = B$ when upstream firms compete and $i = C$ when an upstream cartel forms. It is assumed that the products in a product category are homogeneous, i.e., that their perceived quality level is identical and that $q_h^i > q_l^i > 0$.

[6]See Reiss and Wolak (2007) for a comprehensible introduction to the theory of structural econometric modeling.

[7]Some retailers have successfully placed high-quality private label products (see, e.g., ter Braak et al. 2013).

[8]In terms of sales, Germany's largest supermarket chain *Lidl* (part of Schwarz-Gruppe) produced in 2021 about a quarter of the private labels it sells in-house (this share is expected to increase further). A retailer could also buy the private label product from a cartel outsider at a wholesale price that is close to marginal costs (see Sayman and Raju 2007). Since purchases of low-quality products are often tendered annually, retailers can essentially dictate the desired level of quality.

W.l.o.g, we normalize the quality level of the branded product to $q_h^B = 1$. The product quality perceived by the end customer is determined, e.g., by the packaging of the product, the advertising effort, or the ingredients. Some of these features are easy to adjust, others are time-consuming and costly. However, the retailer is not aware that the change in the market environment is due to a (possibly) temporary shock, as he is not aware of the existence of the cartel. So the retailer will adjust the quality level of the private label product if it increases his profit. It is plausible to assume that customers experience the new product features promptly. For example, they perceive the change to more environmentally friendly packaging immediately.

At the upstream level, branded products are produced at a constant unit cost of $c_u > 0$ and sold to retailers at the wholesale price w^i. When firms compete, we assume that the wholesale price is equal to the unit cost of production, that is, $w^B = c_u$.[9] This may be due to intense upstream competition à la Bertrand or high bargaining power of retailers.[10] To increase the profit margin, brand manufacturers that share a common discount factor $\delta \in (0, 1)$ can enter into an industry-wide cartel agreement.[11] We then assume that they set the joint profit-maximizing wholesale price, fix the quality level at $q_h^B = q_h^C = 1$, and allocate demand equally among members. Thus, cartel members fix the price and the quality level of the product: only if all relevant product characteristics have been fixed between them, competition can effectively be restricted (see, e.g., Steen and Sørgard 2009 on the theory of 'semicollusion' and Schinkel and Spiegel 2017 for an example in the context of 'green cartels').[12]

[9]The main results would also hold for $w^B > c_u$ as long as it is profitable for firms to form a cartel.

[10]See, Ailawadi (2001) for a survey on bargaining power between retailers and manufacturers, Draganska et al. (2010) for an estimation of bargaining power in the German ground coffee market, and Gaudin (2018) on how market concentration affects bargaining power and therefore the equilibrium prices in vertical related markets.

[11]See, e.g., Hasnas and Wey (2015), Bos and Marini (2019), Gabszewicz et al. (2019), Merker (2019) and Bos et al. (2020) for an examination of cartel stability and cartel formation when products are differentiated.

[12]A quality level $q_h^C < q_h^B = 1$ cannot be profit maximizing since competition between the low- and the high-quality product would be fostered. Whether a quality level $q_h^C > 1$ leads to increasing collusive profits depends on the upstream production costs: below, we assume that production costs for the low quality product are convex in its quality level. If this is also true for the branded product, the quality adjustment of the branded producers is small compared to the quality adjustment of the private label product. Thus, assuming that $q_h^C \approx 1$ maximizes collusive profits implies significant costs of raising the quality level for the high-quality product.

When upstream firms form a cartel, it is detected by the competition authority with an annual probability $\alpha \in (0,1)$, which is taken to be independent of the market price as, e.g., in Katsoulacos et al. (2020). After detection, members must pay a multiple $\tau > 0$ of their one-period profit as a penalty, and they will revert to anticompetitive behavior with probability $\gamma \in [0,1]$. In addition, we assume for now that the branded product manufacturers are liable for multiple $\beta > 0$ of the *retailer's* annual overcharge damage.[13] In the US, end users have no standing to sue; in the EU, their incentives to recover damages are low (the phenomenon of injured parties not claiming damages when the expected costs exceed the expected returns from litigation is known as *rational apathy* as discussed, e.g., in Van de Bergh 2013 or Wardhaugh 2014). In Section 4 we discuss how a change in the legal environment affects the market outcome.

Upstream firms are assumed to play Nash reversion strategies, that is, after a firm deviates, they choose competitive prices forever. Whether it makes sense to include fines for deviating firms in the model presented is controversial. On the one hand, this would increase cartel deterrence; on the other hand, there is little evidence that a deviating firm receives special treatment from antitrust authorities.[14] Although cartel sustainability depends on this assumption, our main results are independent of it. We evaluate cartel sustainability in both scenarios.[15]

At the downstream level, a retailer's production function for the branded product is $y = f(x) = x$, where x refers to the input and y refers to the output good, that is, there are no losses in the supply chain. The unit cost of selling a branded product is w^i, and the unit cost of selling (or producing) the private label product is assumed to be convex in the quality level, i.e., $c(q_l^i) = q_l^{i2}$ (see, e.g., Lambertini and Orsini 2000). We do not consider additional retailer-specific selling costs that may cause price differences

[13]For simplicity, we only consider annual damages, as, e.g., in Katsoulacos et al. (2020). By scaling β, it would be possible to consider treble damages or interest.

[14]Hviid and Stephan (2009) argue that Carbide/Graphite Group (C/G) did not receive special treatment from the Eurupean Commission after the discovery of the graphite electrodes cartel, although C/G doubled its output during the cartel period.

[15]Including leniency programs where the leniency applicant is not subject to private and public antitrust enforcement is feasible in the model presented here. Then, a firm will file a leniency application during the period in which it deviates (see Aubert et al. 2006). Thus, a firm's incentive to deviate from the cartel agreement does not depend on whether it is excluded from liability because it has filed a leniency application or because a deviating firm is generally not liable (see, e.g., Buccirossi and Spagnolo 2007 on the theory of leniency).

across retailers.

In deriving market demand, we assume that final consumers choose the preferred retailer mainly depending on factors such as store *appearance and environment* (e.g., a store's layout), store *convenience* (e.g., multi-payments alternatives), store *employees*, or *bonus programs*.[16] For the products in our focus, price differences across retailers and quality differences between private label products are likely to play only a minor role in final consumers' purchasing decisions.[17] The retailer then acts as a monopolist for the considered products and profit-maximization implies that prices for branded products are identical, as sale costs do not differ. Final consumers have two products available that could satisfy their demand: a high-quality product and a low-quality product. It is assumed that each customer buys at most one unit of the product. His or her willingness to pay is $q_j^i\theta$ with $j \in \{l, h\}$, $i \in \{B, C\}$, and $\theta \sim U(0, 1)$ (see Mussa and Rosen 1978). The mass of final consumers who choose a particular retailer is normalized to 1.

In the 'but-for' scenario, upstream firms compete. The timing is as follows:

1. Upstream firms can either compete or collude.

2. The retailer sets profit-maximizing prices and adjusts the profit-maximizing quality level of the private label product if the wholesale price is higher than in the but-for scenario.

3. Final consumers make their preferred purchasing decisions.

The subgame perfect Nash equilibrium can be obtained by backward induction.

[16] Coelho do Vale et al. (2016) provides an overview on what drives consumer loyalty to stores. They also investigate how private labels can help increase store loyalty. Recently, digital loyalty cards have become increasingly important. The '*Lidl* plus app', e.g., has already been downloaded more than 10 million times.

[17] Let us take a kilo of *Südzucker* brand sugar as an example. In Germany, it costs about 0.7 euros at *Lidl*, while the same product costs about 1.2 euros at competing supermarket chains *Rewe* and *Edeka*. This price difference of more than 70% can be explained by other factors of consumer loyalty to stores that affect customers' willingness to pay. Other examples include the numerous auto parts cartels. Since store loyalty (i.e. brand awareness) to some car manufacturers is high, it is likely that customers will not switch car brands but only adjust vehicle features (e.g. steering wheel, seat belts, lighting) if the range of available options has changed due to a cartel agreement.

2.2. Market Equilibrium

We start by deriving the product specific demand. Buying a product is (weakly) preferred to not consuming it only if

$$q_j^i\theta - p_j^i \geq 0 \Leftrightarrow \theta \geq \frac{p_j^i}{q_j^i} =: \bar{\theta}_j^i \tag{1}$$

with $j \in \{l, h\}$ and $i \in \{B, C\}$. A customer is indifferent between the branded and the private label product if

$$\theta - p_h^i = q_l^i\theta - p_l^i \Leftrightarrow \theta = \frac{p_h^i - p_l^i}{1 - q_l^i} =: \tilde{\theta}^i. \tag{2}$$

We assume that demand for the branded product is strictly positive:

$$D_h^i(p_l^i, p_h^i, q_l^i) > 0 \Leftrightarrow \tilde{\theta}^i < 1 \Leftrightarrow q_l^i - p_l^i < 1 - p_h^i. \tag{POS}$$

Assumption (POS) is satisfied if the retailer's (absolute) price-cost margin for the branded product is higher than for the private label product.[18] Then, the retailer will offer the high-quality product at a price where some final customers will buy the product. We derive below that the retailer will also offer the private label product. Final consumers with $\theta \in (0, {}^{p_l^i}/_{q_l^i})$ will not consume any of the products. The demand for the two products is $D_h^i(\cdot) = 1 - \tilde{\theta}^i$ and $D_l^i(\cdot) = \tilde{\theta}^i - \bar{\theta}_l^i$.

Profit-maximization of the retailer.

Prices that maximize a retailer's profit

$$\pi_r^i(p_l^i, p_h^i, q_l^i) = (1 - \tilde{\theta}^i)(p_h^i - w^i) + (\tilde{\theta}^i - \bar{\theta}_l^i)(p_l^i - q_l^{i2}) \tag{3}$$

are

$$\bar{p}_h^i := \frac{1 + w^i}{2}, \quad \bar{p}_l^i := \frac{q_l^i(1 + q_l^i)}{2}. \tag{4}$$

It follows directly from the retailer's profit-maximizing price choice that half of the

[18] Marketing managers tend to focus on the percentage margin (see Farris et al. 2010), which often differs across categories (see Ailawadi and Harlam 2004) and at the product level (see ter Braak et al. 2013). Since in the introduced model, final customers buy only one unit of the product, we focus on the absolute margin. Note, however, that a larger absolute margin of the branded product does not imply a larger percentage margin. In contrast, the percentage margin on sales of private label products is almost always larger in the introduced market environment, regardless of whether the upstream firms compete or collude. This is consistent with the studies mentioned above.

cost effect (i.e., the increased wholesale price) is passed on to the final customers.[19]

The margin for the branded product is $\bar{m}_h^i := \bar{p}_h^i - w^i = 1 - \bar{p}_h^i$; the one for the private label product is $\bar{m}_l^i := \bar{p}_l^i - q_l^{i2} = q_l^i - \bar{p}_l^i$. Thus, the profit per unit from selling a product is identical to the net utility from buying it for $\theta = 1$ (see Figure 1 below).

Inserting the profit-maximizing prices, $\tilde{\theta}^i$ as well as $\bar{\theta}_l^i$ into equ. (3) yields

$$\pi_r^i(\bar{p}_l^i, \bar{p}_h^i, q_l^i) = \frac{q_l^{i3} + (w^i - 1)^2 - 2q_l^{i2}w^i - q_l^i(1 - 2w^i)}{4(1 - q_l^i)}, \tag{5}$$

and therefore[20]

Lemma 1. *The profit-maximizing quality level of the private label product is*

$$\bar{q}_l^B := \frac{3 - (9 - 8c_u)^{\frac{1}{2}}}{4} \quad \textit{and} \quad \bar{q}_l^C := \frac{3 - \left(9 - 8w^C\right)^{\frac{1}{2}}}{4}$$

with $\bar{q}_l^C > \bar{q}_l^B > 0$ *and* $D_l^i(\cdot) > 0$.

Assumption (POS) is satisfied if $c_u \in (0, 7/9)$. If the unit cost of production and hence the wholesale price were too high, the retailer would offer only the private label product. With $c_u > 0$, both product categories are sold and the retailer will increase the quality level of the private label product if an upstream cartel is formed. The intuition is as follows: Assume that upstream firms compete. A declining quality level of the private label product leads to more final customers that are active (i.e., $\bar{\theta}_l^i$ decreases because $\partial\bar{\theta}_l^i/\partial q_l^i > 0$), and $\tilde{\theta}^B$ is shifted to the left, leading to an increasing demand for the branded product, which has a higher profit margin. However, the profit margin for the private label product decreases when its quality level decreases.[21] The retailer chooses a quality level that offsets those effects. If an upstream cartel is formed, the profit margin of the high-quality product decreases while the other effects remain unaffected. In this case, the quality level and also the market price of the private label product increase.

[19] For a detailed discussion on the theory of pass-on see European Commission (2019). Several papers estimate the pass-on rate in specific markets, e.g., Bonnet et al. (2013) in the ground coffee market or Haucap et al. (2021) in the disposable diaper market. That the pass-on rate in the introduced model does not depend on the number of vertically differentiated products offered by the retailer was shown by Bos et al. (2020).

[20] All proofs are in the appendix.

[21] That the profit margin of the private label product increases with its quality level holds for $q_l^i < 1/2$. A quality level $q_l^i \geq 1/2$ would be profitable only if $w^i \geq 1$. Then assumption (POS) would be violated.

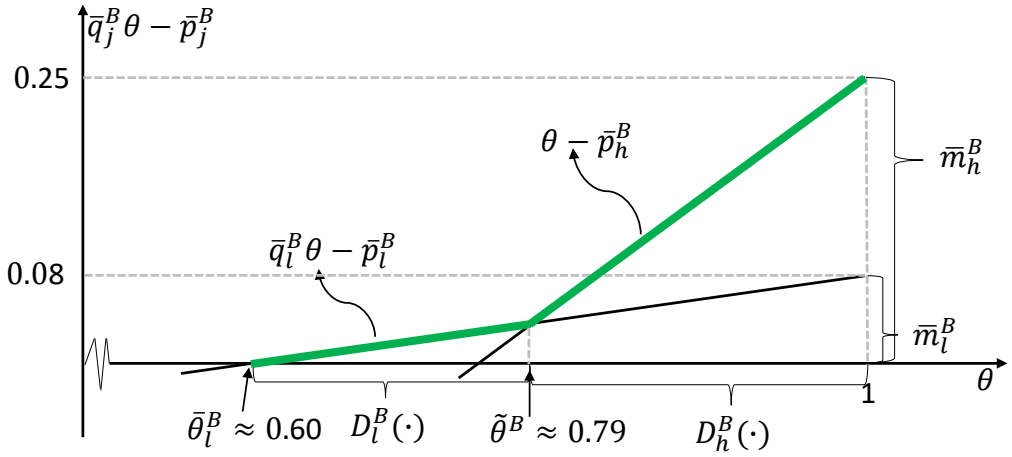

Figure 1: Competitive market outcome for $c_u = 1/2 = w^B$

Knowing the optimal price-quality pair of the private label product allows us to illustrate the net utility lines of the final customers when upstream firms compete (see Figure 1).[22] The net utility levels for customers buying a product are highlighted thick and green.

Profit-maximization in the upstream market.

If upstream firms are liable only for (a multiple of) overcharge damages, the expected compensation payments are $\alpha\beta(1-\tilde{\theta}^C)(w^C - c_u)$. Hence, the industry-wide discounted collusive profit is

$$\pi_u(w^C) = \frac{1-\alpha(\tau+\beta)}{1-\delta+\delta\alpha(1-\gamma)}(1-\tilde{\theta}^C)(w^C - c_u). \tag{6}$$

We assume that $1-\alpha(\tau+\beta) > 0$: antitrust enforcement does not lead to full deterrence, i.e., if firms' discount factors are sufficiently close to 1, a cartel forms. This is consistent with the observation that cartel disclosures occur regularly in vertically related markets. The profit-maximizing wholesale price then depends on neither private nor public antitrust enforcement, since both simply scale $(1-\tilde{\theta}^C)(w^C - c_u)$ down. We can conclude:

Lemma 2. *When an upstream cartel forms, the profit-maximizing wholesale price is*

$$\bar{w}^C := \frac{1-\bar{q}_l^C + \bar{q}_l^{C2} + c_u}{2} = \frac{109 - 5\sqrt{67-54c_u} + 54c_u}{162}.$$

The wholesale price increases in unit production costs. However, the cartel's profit

[22] All numbers in figures 1 and 2 are rounded to two decimal places.

margin is decreasing in c_u with $w^C = c_u$ for $c_u = 7/9$. Then assumption (POS) would be violated and demand for the branded product would fall to zero.

Although the wholesale price does not depend on antitrust enforcement, cartel sustainability does. First, note that a deviating firm's profit-maximizing strategy is to slightly undercut the wholesale price w^C. In this case, the retailer will only supply the product of the deviating firm, and a cartel member's one-shot deviation profit is approximately equal to the one-shot product-wide cartel profit. If the deviating firm is not subject to public and private antitrust enforcement, a cartel is sustainable if:[23]

$$\frac{\pi_u(w^C)}{n} \geq (1-\tilde{\theta}^C)(w^C - c_u) \Leftrightarrow \delta \geq \frac{n-1+\alpha(\tau+\beta)}{n(1-\alpha(1-\gamma))} =: \delta^C. \tag{7}$$

Equilibrium Market Demand.
From $\bar{w}^C > c_u$ and $\bar{q}_l^C > \bar{q}_l^B$, we can directly conclude that $\bar{p}_h^C > \bar{p}_h^B$ and $\bar{p}_l^C > \bar{p}_l^B$ holds. This allows to order the demand functions as follows

Proposition 1. *Product-specific demand in the two market environments satisfies*

(i) $D_h^B(\cdot) > D_h^C(\cdot)$.

(ii) $D_l^C(\cdot) > D_l^B(\cdot)$.

(iii) $D_h^B(\cdot) + D_l^B(\cdot) > D_h^C(\cdot) + D_l^C(\cdot)$.

Several effects influence product-specific demand when an upstream cartel forms. First, as discussed above, $\bar{\theta}_l^C > \bar{\theta}_l^B$ because $\partial\bar{\theta}_l^i/\partial q_l^i > 0$. Thus, total demand decreases when an upstream cartel forms (Part (*iii*)). Second, the slope of the net utility line $q_l^i\theta - p_l^i$ is increasing in the quality level. Then the position of the indifferent customer, $\tilde{\theta}^C$, is shifted to the right. Third, since the wholesale price increases when an upstream cartel forms, $\tilde{\theta}^C$ is shifted to the left. In summary, we show in Appendix A3 that demand for the private label product is higher when a cartel forms compared to the competitive market environment, while demand for the branded product is lower.

[23] Suppose a deviating firm is penalized by the authority and externally liable, then the cartel would be sustainable if $\delta \geq (n-1)/n(1-\alpha(1-\gamma))$.

3. Cartel Damages

With an increasing wholesale price, the market price of branded products also increases, as half of the damage is passed on to final customers. Moreover, the retailer's best response to the rising wholesale price is to raise the price-quality level of the private label product. Then, all final customers who used to buy a product when upstream firms were competing are affected by the cartel agreement. The change in the market environment that results from a cartel outsider responding competitively to the agreed behavior of a partial cartel is referred to as the *umbrella effect* of the cartel.[24] In other words, the harm caused by a partial cartel depends on the behavior of non-cartel members.

The market outcome in the two scenarios where upstream firms either compete (B) or collude (C) is shown in Figure 2 for $c_u = 1/2$. The net utility lines $\bar{q}_l^B\theta - \bar{p}_l^B$ and $\theta - \bar{p}_h^B$ are taken from Figure 1. The dotted purple line illustrates a customer's net utility from buying the private label product at quality-price pair $(\bar{q}_l^C, \bar{p}_l^C)$. The net utility that customers derive from buying the branded product is on the red dashed line when a cartel is operating. As above, the net utilities of customers purchasing a product are highlighted in thick and green. On the line perpendicular to $\theta = 1$, the margins of the retailer are plotted with $\bar{m}_h^B > \bar{m}_h^C > \bar{m}_l^C > \bar{m}_l^B$.

Final consumers with a rather low willingness to pay for quality are negatively affected by the retailer's quality adjustment, since prices are identical for all customers in a product category, but shifts in the quality level give customers with a higher willingness to pay for quality a greater advantage. In the illustrated scenario, this even leads to some final consumers being better off in the cartelized market than without the agreement, that is, $\bar{q}_l^C\theta - \bar{p}_l^C$ is highest for $\theta \in (\theta_L, \theta_U)$.[25] We address this observation in Proposition 2.

For the example illustrated in Figure 2, the difference in consumer surplus related

[24] In general, cartelists may adjust, e.g., product price, quality, quantity offered or other competitive parameters such as advertising effort.

[25] Rounded to three decimal places, $\tilde{\theta}^B = 0.786$ and $\theta_U = 0.792$.

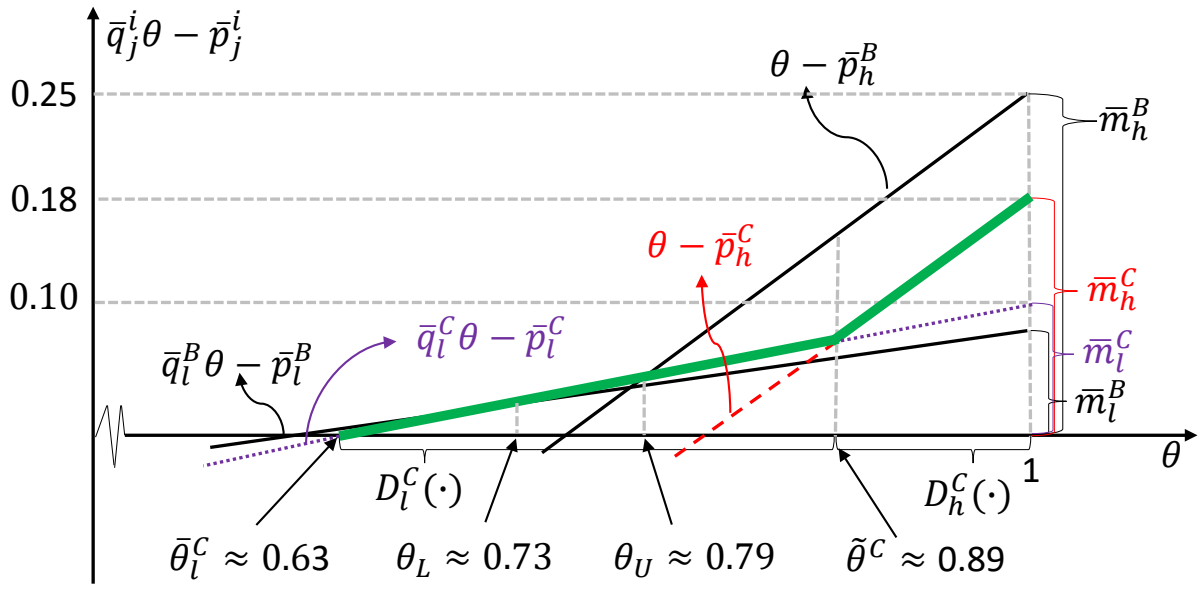

Figure 2: Market outcome for $i \in \{B, C\}$ and $c_u = 1/2$

to the competitive market environment can be broken down as follows:

$$\begin{aligned}\Delta CS^C = &\int_{\bar{\theta}_l^B}^{\bar{\theta}_l^C} (\bar{q}_l^B\theta - \bar{p}_l^B)d\theta + \int_{\bar{\theta}_l^C}^{\theta_L} \Big((\bar{q}_l^B\theta - \bar{p}_l^B) - (\bar{q}_l^C\theta - \bar{p}_h^C)\Big)d\theta \\ &- \left(\int_{\theta_L}^{\tilde{\theta}^B} \Big((\bar{q}_l^C\theta - \bar{p}_l^C) - (\bar{q}_l^B\theta - \bar{p}_l^B)\Big)d\theta + \int_{\tilde{\theta}^B}^{\theta_U} \Big((\bar{q}_l^C\theta - \bar{p}_l^C) - (\theta - \bar{p}_h^B)\Big)d\theta \right) \\ &+ \int_{\theta_U}^{\tilde{\theta}^C} \Big((\theta - \bar{p}_h^B) - (\bar{q}_l^C\theta - \bar{p}_l^C)\Big)d\theta + \frac{OD_h}{2} \end{aligned} \tag{8}$$

with

$$OD_h := (\bar{w}^C - c_u)(1 - \tilde{\theta}^C). \tag{9}$$

ΔCS^C is positive if consumer surplus decreases when a cartel operates. Conceptually, ΔCS^C can be divided into two components: the overcharge damage borne by final customers arising by buying the branded product, i.e., $OD_h/2$, and the net utility loss associated with the private label product, i.e., $ND_l := \Delta CS^C - OD_h/2$. While $OD_h/2$ represents a redistribution of money between final customers and the upstream firms, ND_l consists of a change in social welfare and a redistribution of money between the retailer and the final customers. The components of ΔCS^C are now discussed in detail.

The first addend of ΔCS^C reflects that some customers with a low willingness to pay for product quality are no longer active in the market because the price-quality level of the private label product has increased. This leads to a decrease in social

welfare. The second addend represents the loss in consumer welfare when customers whose willingness to pay for quality lies in $\theta \in (\bar{\theta}_l^C, \theta_L)$ purchase the private label product despite $\bar{p}_l^C > \bar{p}_l^B$ and $\bar{q}_l^C > \bar{q}_l^B$. For these customers, the increasing quality level of the private label product cannot outweigh the price increase. Customers whose willingness to pay for quality lies in $\theta \in (\bar{\theta}_l^B, \theta_L)$ would have been better off if the private label product had not been affected by the cartel agreement.

Let us now consider the last line of ΔCS^C. Customers whose willingness to pay for quality satisfies $\theta > \theta_U$ have bought a branded product in the competitive market environment and are worse off in the cartelized market: either they are harmed because they bought the branded product at supracompetitive prices, or their net utility has decreased because they substituted the branded product in favor of the private label product. In the second case (first addend), falling prices when buying the private label product cannot compensate for the drop in quality from 1 to q_l^C.

Finally, let us consider the middle expression that enters negatively into ΔCS^C. The first addend refers to final consumers who do not change their consumer behavior despite a cartel operates, but prefer the market environment C: the rising quality level more than compensates for the price increase of the private label product. The second addend represents the increase in consumer surplus for those customers who benefited from the substitution of the branded product in favor of the private label product (whose quality has increased). We can conclude:

Proposition 2. *Final consumers whose willingness to pay for quality satisfies* $\theta \in (\theta_L, \theta_U)$ *with*

$$\theta_L := \frac{10 - (9 - 8c_u)^{\frac{1}{2}} - \left(9 - 8\bar{w}^C\right)^{\frac{1}{2}}}{8} \quad \textit{and} \quad \theta_U := \frac{8c_u - 7 + 5\left(9 - 8\bar{w}^C\right)^{\frac{1}{2}} + 4\bar{w}^C}{4\left(1 + \left(9 - 8\bar{w}^C\right)^{\frac{1}{2}}\right)}$$

benefit from the cartel agreement, iff $c_u \in [3/10, 7/9)$.

To see why some customers are better off only when unit production costs c_u are sufficiently high, note that a customer's net utility $\bar{q}_l^B\theta - \bar{p}_l^B$ increases with the quality level but decreases with the price. Thus, it can only be true that the increase in quality of the private label product dominates its price increase for some θ if $\tilde{\theta}^B$ is sufficiently high. This is true for high unit production costs, since $\bar{p}_h^{B'} > \bar{p}_h^B$ follows from $c' > c$ and fewer customers will buy the high-quality product, i.e., $\tilde{\theta}^{B'} > \tilde{\theta}^B$.

The fact that some final customers' net utilities increase when a cartel operates may not be true in standard price or quantity competition, i.e., assuming that prices are strategic complements and quantities are strategic substitutes: although the responses by non-cartel members may mitigate the negative effects of a cartel, for example, by expanding output, all customers lose when a (profitable) partial cartel operates. In other settings, prices of cartel outsiders may even decrease if cartel members increase their prices, e.g., when firms compete in setting prices and prices are strategic substitutes (see Berry and Pakes 1993). Focusing on price and quality competition, Fershtman and Pakes (2000) show that all customers may benefit from a cartel agreement if customers are symmetric and if firms can invest in the product quality and enter and exit from the market. They argue that introducing customers that differ in their income would separate them into two groups: customers with low income would be worse off in case a cartel operates and customers with a sufficiently high income would benefit from collusive behavior. This is not the case in the investigated market environment where only some customers with a medium willingness to pay for quality may benefit whereas customers both with high and low willingness to pay for quality will loose when an upstream cartel forms.

Although some final customers may benefit from a cartel, aggregate consumer welfare declines even if the overcharge damage caused by the purchase of the branded product is compensated, since $ND_l = \Delta CS^C - {}^{OD_h}/_2 > 0$, as shown in Figure 3. So, the negative price effect, that is, $\bar{p}_l^C > \bar{p}_l^B$, outweighs the increase in the customers' net utilities from raising the quality level of the private label product.

The retailer also suffers two types of damages, namely the portion of the cost increase that is not passed on to end customers (i.e., ${}^{OD_h}/_2$) and the 'loss of profits' ($LP_l := \pi_r^B(\cdot) - \pi_r^C(\cdot) + {}^{OD_h}/_2$). The latter is composed of three parts: First, some end users leave the market because the price of the private label product has increased. Second, the price-cost margin *decreases* for customers who substitute the branded product in favor of the private label product. Third, the price-cost margin *increases* for customers who bought the private label product regardless of whether there was a cartel or not, that is, $\bar{m}_l^C > \bar{m}_l^B$. The fact that the retailer is harmed even if it is compensated for the overcharge damage and LP_l is therefore positive is illustrated in Figure 3.

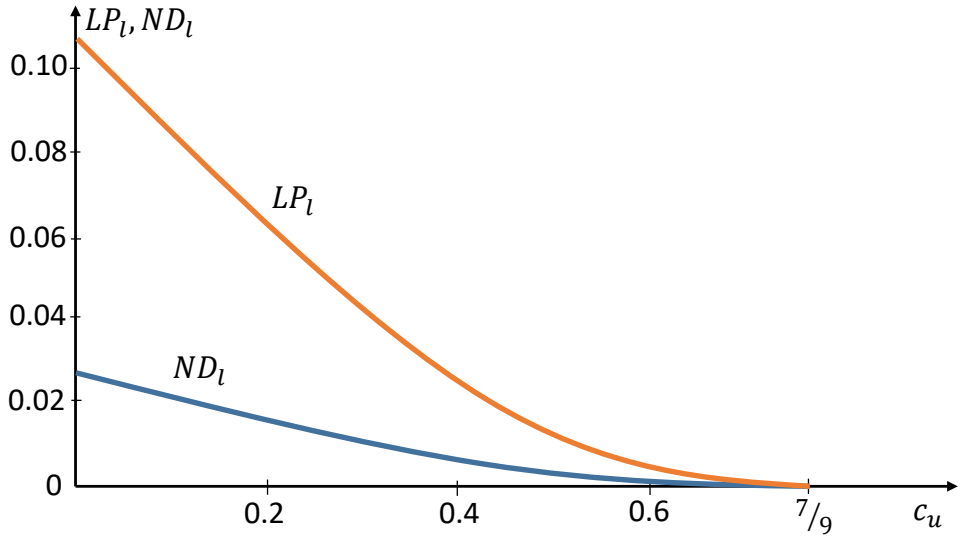

Figure 3: Final customers and the retailer are harmed, even if OD_h is to be compensated

4. Compensation of Injured Parties

First, we discuss how compensation for damages not directly related to the purchase (or sale) of a branded product affects the market environment. Sections 4.2 and 4.3 then examine the issues that arise in compensating retailers and end users.

4.1. Market Outcome under Compensation for Harm in Conjunction with Outside Goods

In general, expected compensation payments for cartel members can affect the market price through two channels. First, an increase in expected compensation payments may lead to an increase in cartel deterrence. This can lead to fewer cartels being formed and effective competition. Second, even if a cartel forms, profit-maximizing pricing decisions may depend on expected compensation payments.

To see how increasing expected compensation payments affect the market outcome in the model presented, we consider a concrete numerical example. Let us assume that harmed parties successfully recover a share $\beta = {}^2/_3$ of the overcharge damage $(1 - \tilde{\theta}^C)(\bar{w}^C - c_u)$ and that the retailer reclaims the loss of profits that results because some customers substituted the branded product in favor of the private label product with the same probability. Further, let the cartel's detection probability be $\alpha = {}^1/_2$, expected fines be zero and assume that four brand product manufacturers form an industry-wide brand product cartel. Finally, we assume that the deviating firm is not subject to private antitrust enforcement and that firms revert directly to collusion after

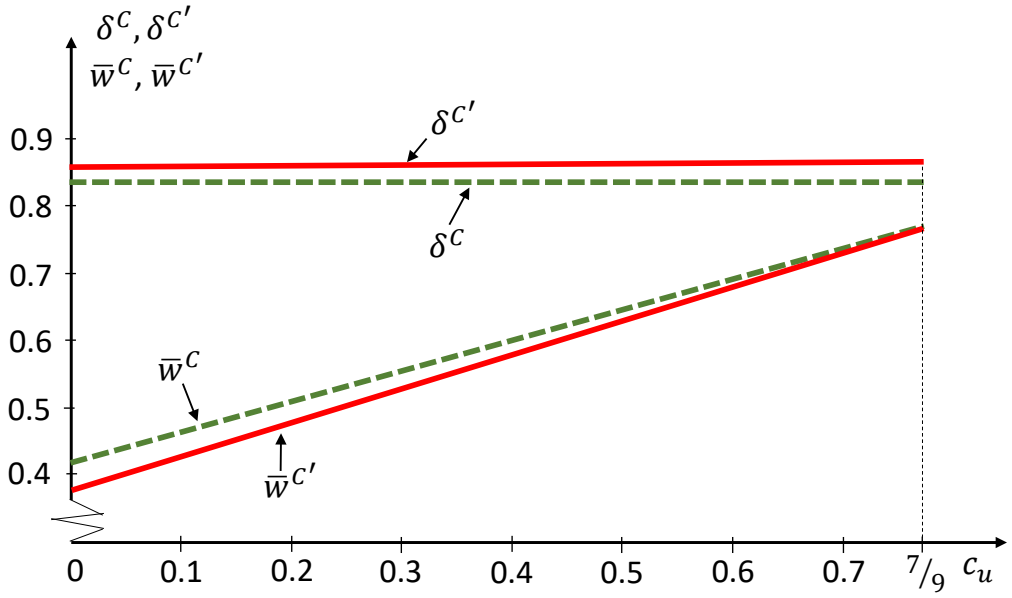

Figure 4: Wholesale price and critical discount factor depend on expected compensation payments

the cartel is uncovered, that is, $\gamma = 1$.[26]

Figure 4 shows the wholesale price and the critical discount factor for the two cases when only the overcharge damage is to be compensated (green, dashed), or when final customers also recover share $^2/_3$ of their net utility decrease (red). The latter scenario is identified by a dash. The wholesale price $\bar{w}^C$ increases in c_u and decreases in the expected compensation payments.[27] The difference between wholesale prices in the two scenarios decreases in c_u, as does the overcharge damage. That some end users benefit when a cartel operates also holds for $\bar{w}^{C'} < \bar{w}^C$. In particular, the lower bound on costs that ensures $\theta_L < \tilde{\theta}^B$ decreases as the retailer's price-quality adjustment weakens, i.e., the net utility line $\bar{q}_l^C\theta - \bar{p}_l^C$ becomes flatter.

Cartel deterrence increases when expected compensation payments for detected cartel members rise: expected collusive profits decrease, while the deviation profit remains unchanged. If the deviating firm is liable and deviation and collusive profits are affected proportionally by increasing expected compensation payments, we can

[26] We repeated the simulation discussed below assuming different parameter constellations and assuming that the final customers can reclaim the decrease in net utility. As long as the collusive profit remains positive, results are similar but the magnitude differs.

[27] This is consistent with the results in Napel and Welter (2022). They show that the expected market price falls when cartel members' profits decrease disproportionately in the expected compensation payments and capacity-constrained firms compete by setting prices. See Katsoulacos et al. (2020) on how cartel prices are affected when firms are both penalized and externally liable.

conclude that $\delta^C = \delta^{C'}$ as long as the collusive profit remains positive (cf. fn 23).

With respect to effective competition, it is likely that an increase in expected compensation is indeed beneficial. However, the main objective of EU antitrust law is to compensate customers adequately – neither overcompensation nor undercompensation is desirable (see Damages Directive, Article 3(3)). Strengthening effective competition is secondary to this.

4.2. Compensation of the Retailer

The quantification of the retailer's overcharge damage caused by increasing input prices is economically feasible. It can follow the usual procedure for estimating antitrust damages. Depending on the data availability, standard comparator based methods could be used (see, e.g., European Commission 2013). After having correctly quantified the overcharge damage $\bar{w}^C - c_u$, it is relevant to note that the retailer bears only half of it, since the pass-on rate is 50%.

Beside the overcharge damage, the retailer may also reclaim the 'loss of profits'. To quantify this, recall that the "volume" (or "quantity") effect and the loss of profits are not equivalent in the market environment presented here: customers who have stopped buying the private label product leave the market (commonly referred to as the volume effect), but those who have stopped purchasing the branded product remain active and buy the private label product instead. Although the volume effect is rarely compensated in legal practice, its quantification is economically feasible, because the retailer loses the margin $\bar{m}_l^B$ for each end user who leaves the market. However, for the final customers who purchase the private label product when a cartel is operating, the retailer's price-cost margin can either increase or decrease depending on whether the customer bought the private label product before the cartel operated or not. Only a structured model may be appropriate to capture all relevant effects on a retailer's profit (e.g., the change in the mark-up of the private label product caused by increasing production costs).[28]

[28]The drawbacks of market simulation models are well known (see, e.g., Weinberg 2011 and Knittel and Metaxoglou 2011).

4.3. Compensation of Final Customers

It is unlikely that end users in the EU and the US will claim damages: in the US, they have no standing to sue; in the EU, their incentives to seek damages are low. According to Argenton et al. (2020), the absence of *"[c]ollective redress may represent the EU's biggest failure in its attempt to promote compensation and facilitate access to justice"* (recital 6.98). Let us therefore assume that collective redress is promoted and that end users are compensated in a first step for the harm caused by the overpricing of the branded product and, in a second step, must also be compensated for the decrease in net utility from (not) buying the private label product.[29] It should be noted that customers who purchased a private label product prior to the existence of a cartel have legal standing only if tortfeasors are liable for umbrella losses, as in the EU or Canada.[30]

Given the usual limitations in estimating harm caused by the cartel, quantifying the overcharge damage to customers who bought a branded product despite the cartel operated is feasible and conceptually identical to quantifying the share of the overcharge damage borne by the retailer. Their net utilities decrease by the share of the increase in the wholesale price that is passed on by the retailer, i.e., by $\bar{p}_h^C - \bar{p}_h^B$. Since these customers are symmetrically affected by the cartel conduct, the compensation claimed can be distributed evenly across the entire group.

Let us now consider the quantification of the decrease in net utility for those customers who either purchased a private label product or stopped buying the product in the cartelized market. For these customers, the damage (benefit) caused by the cartel depends on the price-quality adjustment of the private label product – and thus on the umbrella effect. Since customers' willingness to pay for quality differs, they are not symmetrically affected by the cartel agreement although they bought an identical product. Finally, note that customers who no longer buy the branded product are still active: their "quantity effect" is reduced by the "substitution effect".[31]

[29] Our focus is on the appropriate compensation of harmed customers. We leave aside other important issues when discussing class actions, such as whether an opt-in or opt-out mechanism should be used.

[30] See CJEU in Kone AG v ÖBB-Infrastruktur AG, 2014 and SCC in Pioneer Crop. v. Godfrey, 2019. The handling of umbrella losses in the US is ambiguous (see 600 F.2d 1148 5th Cir. 1979 and 62 F. Supp. 2d 25 1999 for opposing views).

[31] Even thought the European Commission's Guide on quantifying damages highlights that cus-

There are two legal aspects to consider when compensating customers. First, any customer who bought a private label product prior to the existence of a cartel and continues to buy the private label product in the cartelized market is better off if a detected cartel has to compensate the overcharge damage.[32] Compensation for the overcharge damage borne by final customers is therefore inconsistent with the EU's objective of not overcompensating customers and could lead to similar 'perverse incentives' for customers to sue as compensation for treble damages when individual demand is *not* normalized to 1 and customers anticipate that a cartel is operating.[33] Buyers may increase demand although the price has increased: as long as the cartel members are solvent, the compensation for the overcharge damage will offset the price effect while customers continue to benefit from the quality effect.

Second, as emphasized in the Damages Directive, damages are limited to those parties who have suffered *harm* (e.g., recital 4). Thus, in allocating recovered damages among class members, it is necessary to identify those who have suffered harm (recall that some customers may be better off when a cartel is operating). For this purpose, it is not sufficient to prove that the net utility has decreased due to rising prices.

5. Conclusion

We have derived the market equilibrium in a vertical market where there is a partial cartel between producers of high-quality products while a low-quality product is sold competitively. Assuming that the price and the quality of the low-quality product are endogenous, we have shown that the umbrella effect does not have a clear impact on final customers: both the price and the quality of the low-quality product increase when a cartel operates.

We then pointed out the complexity of estimating the harm to injured parties. Although quantifying the retailer's and the customers' overcharge damage directly

tomers "*[. . .] who have to bear higher costs (for example for the purchase of a substitute good) [. . .] must be able to obtain compensation*" (see European Commission 2013, recital 133), it is not discussed that substitution between products may reduce the lost profit.

[32] This is also true for some customers whose willingness to pay for quality is somewhat higher than $\tilde{\theta}^B$: they will substitute the branded product in favor of the private label product, but the compensation for the overcharge damage more than offsets the net benefit loss due to the declining quality level.

[33] See, e.g., Breit and Elzinga (1974), Salant (1987) or Besanko and Spulber (1990) on how compensation for treble damages affects the market environment.

caused by the cartel is economically feasible, compensation for the harm associated with the sale (or purchase) of the low-quality product is highly complex. The harm per unit to the retailer from the sale of the low-quality product varies, depending on whether or not that product was purchased because the price of the high-quality product increased. Similarly, when a cartel is formed, the harm (or benefit) to a final customer depends on his or her willingness to pay for quality. Treating all end users symmetrically and considering only overcharge damages is inconsistent with adequate compensation of harmed parties. The conclusion by Gaudin and Weber (2021) that the harm to customers is "*[. . .] sizable, both in absolute and relative terms*," is only true from a theoretical point of view if a partial cartel has formed and products are vertically differentiated. From a practical point of view, high burdens as the quantification of a customer's willingness to pay for quality seem to be insurmountable.

Appendix

A1. Proof of Lemma 1

Proof. The retailer's profit-maximizing quality choice must satisfy

$$\frac{\partial \pi_r^i(\bar{p}_l^i, \bar{p}_h^i, q_l^i)}{\partial q_l^i} = \frac{(w^i - q_l^i)(w^i - q_l^i(3 - 2q_l^i))}{4(1 - q_l^i)^2} = 0. \tag{10}$$

The quality levels that solve $(w^i - q_l^i)(w^i - q_l^i(3 - 2q_l^i)) = 0$ are

$$q_{l1}^i := w^i; \quad q_{l2}^i := \frac{3 + \left(9 - 8w^i\right)^{\frac{1}{2}}}{4} \quad \text{and} \quad \bar{q}_l^i := \frac{3 - \left(9 - 8w^i\right)^{\frac{1}{2}}}{4}.$$

Taking the second derivative of $\pi_r^i(\cdot)$ with respect to q_l^i yields

$$\frac{\partial^2 \pi_r^i(\cdot)}{\partial q_l^{i2}} = \frac{q_l^i(3 - (3 - q_l^i)q_l^i) - (2 - w^i)w^i}{2(1 - q_l^i)^3} =: \hat{\pi}_r^i(\bar{p}_l^i, \bar{p}_h^i, q_l^i). \tag{11}$$

Inserting $q_l^i = w^i$ into $\hat{\pi}_r^i(\cdot)$ gives $\hat{\pi}_r^i(\bar{p}_l^i, \bar{p}_h^i, w^i) = {}^{w^i}/_{[2(1-w^i)]}$. Since $\hat{\pi}_r^i(\bar{p}_l^i, \bar{p}_h^i, w^i) > 0$ if $D_h^i(\cdot) > 0$, we can conclude that $q_l^i = w^i$ is a minimum.

Next, consider quality level q_{l2}^i. Since $(9 - 8w^i)^{\frac{1}{2}} > 1$ with $w^i < 1$, it follows $q_{l2}^i > 1$. This implies $q_{l2}^i > q_h^i = 1$; the assumption that $q_l^i < q_h^i$ is violated.

Last, consider quality level $\bar{q}_l^i$. Substituting $\bar{q}_l^i = q_l^i$ into (POS) yields

$$16 - 16w^i > \left(3 - (9 - 8w^i)^{\frac{1}{2}}\right)\left(1 + (9 - 8w^i)^{\frac{1}{2}}\right) \Leftrightarrow 11 - 12w^i > (9 - 8w^i)^{\frac{1}{2}}. \tag{12}$$

Inequality (12) can only be satisfied if $w^i < {}^{11}/_{12}$. If so, we can rewrite (12) as

$$(11 - 12w^i)^2 > 9 - 8w^i \Leftrightarrow 0 < 144w^{i2} - 256w^i + 112 \Leftrightarrow 0 < 9w^{i2} - 16w^i + 7. \tag{13}$$

Inequality (12) is satisfied only if $w^i < {}^7/_9$, since the RHS of (13) is strictly convex in w^i, positive for $w^i \approx 0$, and the first zero point is at $w^i = {}^7/_9$. Moreover, a maximum is reached at $\bar{q}_l^i$: substituting $\bar{q}_l^i = q_l^i$ into $\hat{\pi}_r^i(\cdot)$ and simplifying yields

$$\hat{\pi}_r^i(\bar{p}_l^i, \bar{p}_h^i, \bar{q}_l^i) = \frac{9 - 3(9 - 8w^i)^{\frac{1}{2}} + 2\left((9 - 8w^i)^{\frac{1}{2}} - 4\right)w^i}{4(w^i - 1)}. \tag{14}$$

The denominator of equation (14) is negative if assumption (POS) holds. Its numerator

is positive because it is zero for $w^i \in \{0,1\}$ and strictly concave in $w^i \in (0,1)$ with

$$\frac{\partial^2\Big(9-3(9-8w^i)^{\frac{1}{2}}+2\Big((9-8w^i)^{\frac{1}{2}}-4\Big)w^i\Big)}{\partial w^{i2}} = \frac{96(w^i-1)}{(9-8w^i)^{3/2}} < 0. \tag{15}$$

That $\bar{q}_l^i > 0$ follows from $w^i \geq c_u > 0$. This also implies $\bar{\theta}_l^i > 0$. To conclude that demand for the private label product is positive, it is needed that

$$\bar{\theta}_l^i < \tilde{\theta}^i \Leftrightarrow \frac{p_j^i}{q_j^i} < \frac{p_h^i - p_l^i}{1-q_l^i} \Leftrightarrow \frac{1+q_l^i}{2} < \frac{1+w^i-q_l^i(1+q_l^i)}{2(1-q_l^i)} \Leftrightarrow q_l^i < w^i. \tag{16}$$

Substituting $q_l^i = \bar{q}_l^i$ into $q_l^i < w^i$ gives

$$(9-8w^i)^{\frac{1}{2}} > 3-4w^i. \tag{17}$$

Inequality (17) must be satisfied for $1 > w^i \geq 3/4$. For $w^i < 3/4$ it is also satisfied, since

$$(9-8w^i)^{\frac{1}{2}} > 3-4w^i \Leftrightarrow 9-8w^i > (3-4w^i)^2 \Leftrightarrow 16w^i > 16w^{i2}, \tag{18}$$

which holds for $w^i < 1$. □

A2. Proof of Lemma 2

Proof. Inserting $\bar{p}_l^C$, $\bar{p}_h^C$ and $\bar{q}_l^C$ into $\tilde{\theta}^i$ gives

$$\tilde{\theta}^C = \frac{1+w^C-\bar{q}_l^C-\bar{q}_l^{C2}}{2(1-\bar{q}_l^C)} = \frac{13-3(9-8w^C)^{\frac{1}{2}}}{8}. \tag{19}$$

The industry-wide profit of upstream firms therefore is

$$\pi_u^C(w^C) = \frac{1-\alpha(\tau+\beta)}{1-\delta+\delta\alpha(1-\gamma)} \cdot (w^C-c_u)\left(1-\frac{13-3(9-8w^C)^{\frac{1}{2}}}{8}\right). \tag{20}$$

Taking the first and the second derivative with respect to w^C and defining the first factor of $\pi_u^C(\cdot)$ as F, yields

$$\frac{\partial\pi_u^C(\cdot)}{\partial w^C} = F \cdot \frac{-5(9-8w^C)^{\frac{1}{2}}+27-36w^C+12c_u}{8(9-8w^C)^{\frac{1}{2}}}, \quad \frac{\partial^2\pi_u^C(\cdot)}{\partial w^{C2}} = F \cdot \frac{3(2c_u-9+6w^C)}{(9-8w^C)^{\frac{3}{2}}}. \tag{21}$$

With $F > 0$, the numerator of $\partial\pi_u^C(\cdot)/\partial w^C$ is zero for

$$\bar{w}^C := \frac{109-5\sqrt{67-54c_u}+54c_u}{162} \quad \text{and} \quad w_2^C := \frac{109+5\sqrt{67-54c_u}+54c_u}{162}. \tag{22}$$

We can exclude w_2^C from the following analysis since $w_2^C > 7/9$ for all $c_u \in (0, 7/9)$. Then the demand for the branded good would be zero. Consequently, $\bar{w}^C$ maximizes the

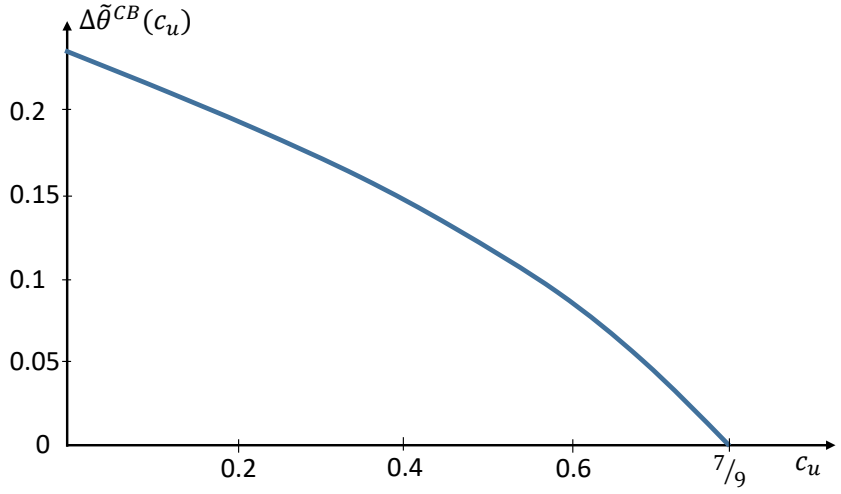

Figure 5: The indifferent customer is shifted to the right if a cartel forms, i.e., $\tilde{\theta}^C > \tilde{\theta}^B$

joint profit of the cartel members, since $^{\partial^2 \pi_u^C(\cdot)}/_{\partial w^{C2}} < 0$ for $\bar{w}^C < 1$. $\bar{w}^C$ is increasing in c_u with $\bar{w}^C = c_u$ for $c_u = {}^7/_9$. □

A3. Proof of Proposition 1

Proof. The position of the customer who is indifferent between buying a private label product and no consumption at all is given by

$$\bar{\theta}_l^i = \frac{1 + q_l^i}{2} \quad \text{with} \quad \frac{\partial \bar{\theta}_l^i}{\partial q_l^i} = \frac{1}{2}. \tag{23}$$

From $\bar{q}_l^C > \bar{q}_l^B$ directly follows $\bar{\theta}_l^C > \bar{\theta}_l^B$. Next, consider the position of the customer who is indifferent between buying the high-quality or the low-quality product. Depending on the market environment, his or her position is given by

$$\tilde{\theta}^B = \frac{13 - 3\sqrt{9 - 8c_u}}{8}; \quad \tilde{\theta}^C = \frac{39 - \left(293 + 20\sqrt{67 - 54c_u} - 216c_u\right)^{\frac{1}{2}}}{24} \tag{24}$$

with $^{\partial \tilde{\theta}^B}/_{\partial c_u} > 0$.

Part (*i*). Consider

$$\Delta\tilde{\theta}^{CB}(c_u) := \tilde{\theta}^C - \tilde{\theta}^B = \frac{9\sqrt{9 - 8c_u} - \left(293 + 20\sqrt{67 - 54c_u} - 216c_u\right)^{\frac{1}{2}}}{24}, \tag{25}$$

with $\Delta\tilde{\theta}^{CB}(0) \approx 0.235$. $\Delta\tilde{\theta}^{CB}(cu)$ is illustrated in Figure 5. It has a unique zero at $c_u = {}^7/_9$. Thus, we can conclude that $\Delta\tilde{\theta}^{CB}(c_u) > 0$ and therefore that $D_h^B(\cdot) > D_h^C(\cdot)$ for $c_u \in (0, {}^7/_9)$.

Part (*ii*). Determining $\Delta D_l^{CB}(c_u) := D_l^C(\cdot) - D_l^B(\cdot)$ yields

$$\begin{aligned}\Delta D_l^{CB}(c_u) &= \tilde{\theta}^C - \bar{\theta}_l^C - (\tilde{\theta}^B - \bar{\theta}_l^B) \\ &= \frac{27 - \left(293 + 20\sqrt{67 - 54c_u} - 216c_u\right)^{\frac{1}{2}}}{36} - \frac{3 - \sqrt{9 - 8c_u}}{4} \\ &= \frac{9\sqrt{9 - 8c_u} - \left(293 + 20\sqrt{67 - 54c_u} - 216c_u\right)^{\frac{1}{2}}}{36}. \end{aligned} \tag{26}$$

$\Delta D_l^{CB}(c_u)$ is positive since $\Delta\tilde{\theta}^{CB}(c_u)$ (see eq. 25) is positive. □

A4. Proof of Proposition 2

Proof. A customer's net utility as the quality level of the private label product increases can only be greatest if it exceeds both $\bar{q}_l^B\theta - \bar{p}_l^B$ and $\theta - \bar{p}_h^B$. Equating $\bar{q}_l^B\theta - \bar{p}_l^B$ with $\bar{q}_l^C\theta - \bar{p}_l^C$ and solving towards θ yields

$$\bar{q}_l^B\theta - \bar{p}_l^B = \bar{q}_l^C\theta - \bar{p}_l^C \Leftrightarrow \theta = \frac{10 - (9 - 8c_u)^{\frac{1}{2}} - (9 - 8\bar{w}^C)^{\frac{1}{2}}}{8} =: \theta_L. \tag{27}$$

θ_L is smaller than $\tilde{\theta}^B$ if

$$\begin{aligned}\theta_L < \tilde{\theta}^B &\Leftrightarrow \frac{10 - (9 - 8c_u)^{\frac{1}{2}} - (9 - 8w^C)^{\frac{1}{2}}}{8} < \frac{13 - 3(9 - 8c_u)^{\frac{1}{2}}}{8} \\ &\Leftrightarrow 2\sqrt{9 - 8c_u} - 3 < (9 - 8w^C)^{\frac{1}{2}}. \end{aligned} \tag{28}$$

Inequality (28) must be satisfied if the LHS is negative. If it is positive, (28) can be written as

$$(2(9 - 8c_u)^{\frac{1}{2}} - 3)^2 < 9 - 8w^C \Leftrightarrow \bar{w}^C < \frac{-9 + 3\sqrt{9 - 8c_u} + 8c_u}{2}. \tag{29}$$

Substituting $\bar{w}^C = {}^{(109 - 5\sqrt{67 - 54c_u} + 54c_u)}/_{162}$ (see eq. 22) and solving towards c_u yields $c_u > {}^{659 - 16\sqrt{433}}/_{1089} \approx {}^{3}/_{10}$. (For $c_u \approx 1.03$, it follows that $\theta_L > \tilde{\theta}^B$.)

Next, consider the customers who substituted the branded product in favor of the private label product when a cartel operates. From $\theta_L < \tilde{\theta}^B$, we can conclude that there must be a $\theta > \tilde{\theta}^B$ where these customers are better off, since $\bar{q}_l^C\theta - \bar{p}_l^C$ must then exceed $\theta - \bar{p}_h^B$ for $\theta \in [\tilde{\theta}^B, \theta_U]$ with

$$\bar{q}_l^C\theta - \bar{p}_l^C = \theta - \bar{p}_h^B \Leftrightarrow \theta = \frac{-7 + 8c_u + 5(9 - 8w^C)^{\frac{1}{2}} + 4\bar{w}^C}{4\left(1 + (9 - 8w^C)^{\frac{1}{2}}\right)} =: \theta_U. \tag{30}$$

□

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