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Information sharing, personalized pricing, and collusion[☆]

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ABSTRACT

We study collusion sustainability in an infinitely repeated game in which firms might price discriminate, by offering personalized prices for the share of consumers they have information about. We do not impose any restrictions to the distribution of consumers and the product characteristic space. In such a general framework we show that when firms share their personal information about consumers, collusion is more difficult to sustain. We also show that, for intermediate levels of the discount factor, an antitrust policy aiming to discourage joint profit maximization and to maximize the consumer surplus should allow information sharing between firms. Instead, a ban on information sharing is optimal only if firms have imperfect information about their own consumers.

1. Introduction

The growth of the digital economy and the development of big data analytics, such as data mining and machine learning techniques, have enabled firms to refine their decision-making processes, to define their strategic choices more consciously and to share more easily the information they acquire. Nowadays, firms are used to adopt tracking tools to identify individual consumers with greater accuracy than even before, with the final aim of offering personalized and tailored prices (Shaffer and Zhang, 2002).[1] However, as discussed by Gu et al. (2019), most of the data a firm can collect are exclusive and confer a competitive advantage with respect to the rival, by leaving the possibility to price discriminate. Hence, such information remains private unless consumers' data are shared with the rival, bought from a third party (e.g., a digital platform) or made public through rules and regulations that increase market transparency.

Although privacy concerns have driven Public Authorities to limit the transfer of personal information (see e.g., the GDPR in Europe and the CPRA in California), little is known about the effects of sharing consumers' data in a dynamic framework, in which firms might collude. Does a legal ban on sharing information facilitate collusion sustainability? By contrast, what is the effect of making the market transparent?

In this paper, we contribute to the current debate in the antitrust literature about the impact of sharing consumers' personal information on collusion sustainability through a simple but general theoretical model. We develop an infinitely repeated game in which firms might offer personalized prices for the share of consumers they have information about. Based on Lederer and Hurter (1986), we study collusion sustainability in a regime with shared or unshared information, and we show that information sharing, by increasing the profits in the case of a deviation from the collusive agreement, makes collusion less sustainable. This highlights a novel tension between transparency and collusion: if price discrimination is viable, sharing information never facilitates the sustainability of a tacit agreement.[2] Furthermore, we show that an antitrust policy aiming to maximize

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[1] This has raised several concerns across regulators and policy makers, who recognized the relevance of this pricing practice, at least from a theoretical point of view (see e.g., OECD, 2018). However, there is no shortage of recent practical cases, as also argued by the CMA (2021). One example is the use of computerized price tags applied on customers' phones to implement dynamic pricing by a British home improvement firm. Based on customers' spending patterns and loyalty card information, an algorithm defines a personalized price.

[2] We show that this result is robust to harsher punishment codes and to imperfect degrees of collusion in Sections 4 and 5.

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the consumer surplus should allow the firms to share their personal information about consumers in the case of an intermediate discount factor; when the discount factor is high or low, banning or not information sharing is irrelevant for the consumer surplus.

We also provide an extension of the model in which firms' decision to share or not information is endogenized and such a possible exchange of information allows firms to improve the degree of accuracy of their consumers' data. In practice, firms jointly commit to one of the alternative information regimes before taking part of the pricing game. We show that the results of the baseline model hold in this setting and, interestingly, when the reservation price is not too large, collusion is more difficult to sustain as the information gathering process is more accurate and orientated toward the closest consumers. This means that, in that case, collusion can be facilitated if firms have a more balanced information between close and far consumers in the market rather than a wider knowledge only about their own consumers. By contrast, knowing better the closest consumers reduces the difference in terms of collusion sustainability between unshared and shared information regimes. Moreover, we point out some differences with respect to the baseline model regarding the optimal antitrust policy. When firms have imperfect information about their own consumers, punishment and collusive profits vary depending on whether information is shared or unshared. Specifically, they diverge as the information becomes less accurate. This leads us to consider not only the information regime that makes collusion more difficult to sustain, but also the optimal policy intervention that maximizes consumer surplus for any discount factor. As for the baseline model, when the discount factor is intermediate, sharing information is optimal as it prevents firms from colluding. However, if the policy intervention cannot affect the sustainability of collusion (because it is, or it is not, enforceable in both information regimes), banning the exchange of information is optimal as it reduces the consumer surplus extraction.

This paper is related to several strands of literature. First, it is related to those papers discussing the implications of information sharing on collusion sustainability. As pointed out by Stigler (1961), there are in theory several profits maximizing price structures. Therefore, colluding firms might find it difficult to coordinate, and information sharing might help firms finding a focal point for coordination. On the other hand, as emphasized by Genesove and Mullin (2001), exchange of information might reduce the monitoring problem: in particular, when it is not easy to distinguish whether changes in the own demand depend on market volatility or on deviation strategies by other firms participating to the agreement, information sharing might help properly detecting deviation and then making collusion more sustainable (Green and Porter, 1984). From a different perspective, Compte (1998) and Athey and Bagwell (2001) prove that sharing information about costs help firms reaching the most profitable collusive equilibrium within the set of the sustainable collusive agreements. Differently from these papers, our paper discusses an exchange of information regarding the preferences of the consumers. Each firm has private information about the preferences of a set of consumers: in the case of information sharing this information becomes available to every firm. We show that in this case collusion is less sustainable, since this kind of information exchange increases the profits in the case of a deviation while it does not affect the profits during the collusive and the punishment stages.

Our paper is closely related also to the growing literature studying the effect of big data and algorithms on collusion sustainability (Calvano et al., 2020a,b; Klein, 2021; Martin and Rasch, 2022). These advanced techniques allow to maintain supra-competitive prices and to make collusion easier to sustain and harder to be detected, so raising several concerns about their use in a dynamic framework (see e.g., OECD, 2017).[3] Therefore, identifying those factors, such as the increase in market transparency, that might facilitate the emergence and sustainability of a cooperative agreement is crucial in order to enforce an efficient anti-cartel policy. This has generated a large discussion between scholars and policymakers about the (potentially anti-competitive) effects of more precise information. For instance, Liu and Serfes (2007), Miklós-Thal and Tucker (2019), and Peiseler et al. (2022) analyse the impact of an increase in the information accuracy, in the sense of a more precise knowledge (Liu and Serfes, 2007, and Miklós-Thal and Tucker, 2019) or lower probability of erroneous signals (Peiseler et al., 2022) about consumers' preferences, on the sustainability of a tacit cartel. While Liu and Serfes (2007) and Miklós-Thal and Tucker (2019) find that more precise knowledge has a negative impact on collusion sustainability, Peiseler et al. (2022) show that greater signal precision has an inverse U-shaped impact.[4] Colombo and Pignataro (2022), instead, investigate the effects of a wider completeness of the information at firms' disposal, and find that more complete information has in general a U-shape impact on collusion sustainability. Interestingly, Sugaya and Wolitzky (2018) share with this paper the idea that a better demand prediction can hinder the sustainability of a tacit cartel by increasing the deviation profits. They focus on a specific collusive strategy – i.e., the home-market principle according to which firms act as local monopolies – and they show that, under some conditions, increasing the market transparency, in terms of firms' ability to monitor their competitors, can make collusion less likely to be sustained.

In contrast to these models, we do not impose any restrictions to the distribution of consumers and the product characteristic space, by providing a general setting that sheds light also on the (negative) effect of sharing information about consumers' preferences and making the market transparent on collusion sustainability.

Finally, our paper also adds to the theoretical IO literature dealing with price discrimination and collusion. The policy debate about banning price discrimination to hinder collusion in a dynamic framework or making it lawful to foster competition in a static game is still open (see e.g., CMA, 2018). Liu and Serfes (2007) and Helfrich and Herweg (2016) argue that a ban on price discrimination has pro-collusive effects. In contrast, Gossl and Rasch (2020) show that the impact of banning price discrimination on collusion sustainability hinges on whether authorities order the use of linear or fixed fees only, whereas, by focusing on history-based price discrimination, Colombo and Pignataro (2022) show that a ban on price discrimination has pro-competitive effects when the degree of information accuracy is sufficiently high. In our paper, we do not consider a complete ban on price discrimination (which remains possible on those consumers each firm has information about), but rather a forbid of information sharing, which amounts preventing each firm to price discriminate by means of personalized prices on consumers belonging to the rival's market.

[3] An objective account of the capabilities of current algorithms to engage both in price discrimination and collusion is provided by Gautier et al. (2020). They address this issue from both an economic and a legal perspective, suggesting a reform of the current rules and enforcement practices governing algorithms and, more generally, artificial intelligence technologies applied in competition.

[4] The differences between the two results can be explained as follows. In Liu and Serfes (2007), the gains from deviating increase faster than the gains from colluding and the losses from competing as the quality of consumer information improves. This comparative statics is even more pronounced in Miklós-Thal and Tucker (2019) as goods are perfect substitutes, and then punishment profits are always equal to zero. Instead, in Peiseler et al. (2022), punishment profits decrease with signal precision, which doesn't affect the collusive profits, whereas it weakly increases the deviation profits. Clearly, these different impacts depend on the type of information received: a wider knowledge of consumers' willingness to pay or a simply better understanding of consumers' brand loyalties.

We show that such a partial ban on price discrimination has pro-collusive effects.

The rest of the paper proceeds as follows. In Section 2 we introduce the model. In Section 3 we derive the main result under a general framework. In Section 4 we provide a robustness check by showing the result in a harsher punishment code and an application in the Hotelling (1929) framework. In Section 6, we extend the model to account for imperfect degrees of collusion and information. Section 7 presents some concluding remarks.

2. The model

Players. There are two firms ($j = A, B$) playing an infinitely repeated price-setting game. Firms are located in a n-dimensional compact and continuous space $S \subset R^n$, which can be interpreted in terms of product characteristics – each dimension represents a particular attribute of the product – or geographical locations – n must be equal to 1 (line), 2 (plane) or 3 (surface). The location of Firm j is $z_j \in S$. Fixed costs are disregarded. Marginal costs are constant and equal to c for both firms. Following Singh and Vives (1984), we consider from now on prices net of marginal costs.

In every period there is a mass of short-lived consumers,[5] each with a unit demand function and location denoted by $z \in S$. Consumers are heterogeneous in their tastes (or in their physical location), as they differ in how much they are willing to pay for the products on sale. They are distributed on S according to a generic density function $\rho(z)$ integrable over S. The "distance" cost of consuming a less-than-preferred variety for consumer z is $t(z_j, z)$, which is assumed to be continuous and integrable in z for any z_j.

Information technology. We denote with $T_j \equiv \{z : t(z_j, z) \leq t(z_{-j}, z)\}$ the turf of Firm j. As in Shaffer and Zhang (2002) and Colombo and Pignataro (2022), each firm owns an information technology that allows it to distinguish the consumers in T_j from those in T_{-j}. Moreover, Firm j knows the exact location of the consumers in its own turf, T_j, whereas it has no information about the consumers in the rival's turf, T_{-j}. Each firm can price discriminate by setting a personalized price, $p_j(z)$, which is function of the consumer's location, for each consumer it has information about, whereas it must charge a uniform price, $\tilde{p}_j$, to the other consumers.

Consumers' preferences. When buying from Firm j, the utility of consumer z is $u_j(z) \equiv v - \varphi_j - t(z_j, z)$, where v is the reservation price, which is assumed to be large enough so that the market is always covered in equilibrium, and $\varphi_j \in \{p_j(z), \tilde{p}_j\}$ is the price set by Firm j, which might be discriminatory ($\varphi_j = p_j(z)$) or uniform ($\varphi_j = \tilde{p}_j$). Following Liu and Serfes (2007), we assume that, in case of indifference, the consumer buys from the closer firm if no firm is deviating from the cartel; otherwise, he buys from the deviating firm.

Information regimes. We consider two alternative information regimes: in the first (*unshared information*), the information owned by each firm is not shared with the rival; in the second (*shared information*), the information is shared, so that each firm has perfect knowledge also about the consumers belonging to the rival's turf. Under shared information, Firm j can set a personalized price $p_j(z)$ to every consumer $z \in S$.

Dynamic strategy. Firms are long-lived and maximize the discounted sum of profits over an infinite horizon at a common discount factor $\delta \in [0, 1]$. We assume perfect monitoring and a *grim trigger* strategy (Friedman, 1971) to sustain collusion – i.e., if one firm deviates from the collusive agreement, there is a reversion to Nash equilibrium in all the subsequent periods. By denoting with π^C, π^D and π^P, respectively the one-shot collusive, deviation and punishment profits, it is well-known that collusion is a Subgame Perfect Nash Equilibrium if and only if $\frac{\pi^C}{1-\delta} \geq \pi^D + \frac{\delta}{1-\delta}\pi^P$, yielding:

$$\delta \geq \delta^* \equiv \frac{\pi^D - \pi^C}{\pi^D - \pi^P} \tag{1}$$

In other words, collusion is sustainable in equilibrium if and only if the (common) discount factor is sufficiently high. Therefore, the critical discount factor measures the degree of collusion sustainability: the greater (lower) the critical discount factor, the smaller (the larger) is the set of discount factors supporting collusion – i.e., collusion is less (more) sustainable.

3. Equilibrium outcomes

We first consider the punishment phase. Lederer and Hurter (1986, Theorem 1) show that, when two firms adopt perfect price discrimination and consumers have unit demand, an equilibrium price exists for any possible location pair in the S-space. The equilibrium is such that the firm which is further from the consumer sets a price equal to zero, while the other firm charges a price which is equal to the transportation costs differential, that is:

$$p_j^P(z) = \begin{cases} t\left(z_{-j}, z\right) - t\left(z_j, z\right) & if\ z \in T_j \\ 0 & if\ z \notin T_j \end{cases} \tag{2}$$

The intuition is the following. Consider a consumer belonging to the turf of Firm j, that is $z \in T_j$. If Firm j does not serve consumer z, it could undercut the rival if the price set by Firm -j is above its marginal cost. For any positive price set by Firm -j, the best-reply of Firm j is therefore $p_j(\varphi_{-j}; z) = \varphi_{-j} + t(z_{-j}, z) - t(z_j, z)$. Then, as long as $\varphi_{-j} > 0$, Firm –j can undercut Firm j. The undercutting process ends when φ_{-j} is equal to zero. Therefore, we get: $p_j^P(z) = t(z_{-j}, z) - t(z_j, z)$. The punishment profits are: $\pi^P = \int_{T_j} p_j^P(z)\rho(z)dz$. Since in equilibrium each firm serves only its own turf, there is no difference between shared and unshared information during the punishment phase.

Now, we consider the optimal collusive prices. Since Firm j knows the location of each $z \in T_j$, the collusive agreement entails a market sharing rule where Firm j serves the consumers belonging to its own turf, T_j, and the collusive price extracts completely the consumer surplus, that is: $p_j^C(z) = v - t(z_j, z)$, with $z \in T_j$, yielding collusion profits equal to $\pi^C = \int_{T_j} p_j^C(z)\rho(z)dz$. As for the punishment stage, under collusion there is no difference between shared and unshared information, as no firm makes use of the information about the consumers belonging to the rival's turf.

Finally, we consider the deviation phase. Suppose Firm j deviates while Firm –j does not. Firm j cannot do better than charging the collusive price schedule, $p_j^C(z)$, to the consumers belonging to its own turf, $z \in T_j$. Instead, it could steal the consumers in the rival's turf, $z \in T_{-j}$, by undercutting the Firm -j's collusive price. First, consider shared information. In this case, Firm j can set a personalized price even for any $z \in T_{-j}$.[6] Second, consider unshared information. Now, Firm j must set a uniform price on consumers $z \in T_{-j}$. It is immediate to observe that the deviation profits in the case of unshared information, say π^D, cannot be larger than the deviation profits under shared information, say $\hat{\pi}^D$. Indeed, the possibility for the deviating firm to adopt price discrimination everywhere does not prevent it from adopting a uniform price, if it is convenient to do so. At the opposite, under unshared information, the

[5] For example, in every period there is a new generation of consumers that completely substitutes the previous one. Therefore, the information about consumers in period t cannot be used to infer the position of consumers in period $t + 1$.

[6] In particular, the deviation price schedule is $p_j^D(z) = p_{-j}^C(z) + t(z_{-j}, z) - t(z_j, z) = v - t(z_j, z)$.

deviating firm is prevented from using price discrimination on the rival's turf even when it would be convenient to adopt it. Therefore, it must be $\hat{\pi}^D \geq \pi^D$.

Hence, firms' profits might differ between shared and unshared information regimes only in the case of deviation. Substituting the firms' profits into (1), it follows that the critical discount factor under shared information, say $\hat{\delta}^*$, is never lower than the critical discount factor under unshared information, say $\breve{\delta}^*$. This implies the following:

Proposition 1. *Under unshared information, collusion is sustainable if and only if* $\delta \geq \breve{\delta}^*$. *Sharing information about consumers never facilitates collusion, being* $\hat{\delta}^* \geq \breve{\delta}^*$.

Therefore, information sharing between the firms about the characteristic of their own consumers makes collusion less likely to sustain when price discrimination is possible. This result echoes the findings of Sugaya and Wolitzky (2018), who argue that, if firms equally share the market in local monopolies, transparency can hinder collusion. However, their result is based on the firms' ability to observe their competitors' prices and sales when demand and cost conditions, which are independent across local monopolies, change over time. In their model, a higher degree of transparency implies more accurate information about the rival's past behaviour which, in turns, allows them to better predict future demand conditions and, under some conditions, to enforce more profitable deviations. In contrast with their model, we provide a rationale for the emergence of tacit cartels in which firms don't share their information about their consumers when firms might charge personalized prices. Although the effect of sharing information is similar – i.e., it increases deviation profits, so decreasing the collusion sustainability – our setup is completely different: collusion is sustained by perfect monitoring, we don't impose any restriction to the demand function (which doesn't change over time as well as the cost function) and cartel members aim at maximizing their joint profits rather than simply segmenting the market according to the home-market principle.[7]

This has relevant implications for an antitrust policy aiming to maximize the consumer surplus.[8] Clearly, in equilibrium, only two cases are possible: a punishment equilibrium (when the discount factor is lower than the critical discount factor), so that the firms play Nash, and a collusive equilibrium (when the discount factor is greater than the critical discount factor). When the common discount factor is greater than $\hat{\delta}^*$, collusion is sustainable under both shared and unshared information. It follows that banning information sharing between the firms is irrelevant for the consumers, as they receive a zero surplus under both information regimes. Similarly, when the common discount factor is lower than $\breve{\delta}^*$, collusion is never sustainable.[9] In this case, we have shown that there is no difference between the two information regimes (indeed, the Nash profits are invariant with the information regimes), so that banning or not information sharing is without consequences for the consumers, as they receive the same positive amount of surplus under both regimes. At the opposite, when the discount factor is between $\breve{\delta}^*$ and $\hat{\delta}^*$, collusion is sustainable under unshared information, but not under shared information. Since the consumer surplus is zero under collusion but positive in the Nash equilibrium, information sharing should be allowed to make collusion unstable and guarantee a positive consumer surplus in equilibrium.

The above discussion is summarized in the following proposition:

Proposition 2. *An antitrust policy aiming to maximize the consumer surplus should allow the firms to share their personal information about consumers when* $\delta \in [\breve{\delta}^*, \hat{\delta}^*]$; *banning or not information sharing is irrelevant in the other cases.*

Proposition 2 has the following implication for the Antitrust Authority. It points out that allowing information sharing might have a beneficial effect, by hindering tacit collusion, for a defined intermediate range of the discount factor. Indeed, colluding through personalized prices, which is easier to sustain if firms don't share their information, maximizes the consumer surplus extraction. Hence, in that region of parameters, any policy intervention that makes the market more transparent rules out the worst-case scenario from the consumers' point of view. Outside that interval, any policy intervention that contributes to make the market more or less transparent is useless to fight collusion.[10] This also implies that, when the discount factor is sufficiently small, firms might secretly communicate only to enforce an explicit agreement (because a tacit agreement is not sustainable), but when the discount factor is sufficiently large, firms are less likely to communicate for collusive purposes (because a tacit agreement is sustainable even in the absence of communications). This should lead an Antitrust Authority to address most of its efforts in detecting explicit cartels when the discount factor is sufficiently small – i.e., when a tacit cartel is more difficult to sustain.

4. Robustness and application

In this section, we provide a robustness check and an application of the model developed up to this point. First, we show that our results in the baseline model are confirmed also in a framework in which firms adopt a harsher punishment code, in the spirit of Abreu (1986 and 1988). Second, we provide an application of our general model by considering the Hotelling (1929) linear model, which allows us to provide closed-form solutions.

4.1. Harsher punishment code

We developed our baseline model by assuming that firms adopt a grim trigger strategy to sustain collusion. This implies that any deviation from the collusive path is punished by playing the Nash equilibrium in all the subsequent periods. Clearly, if products are not perfect substitute, this implies that firms make positive profits along the punishment path. Hence, one may wonder whether and how results might change if firms adopt a harsher punishment code.

To this end, we use the stick and carrot strategy described by Abreu (1986 and 1988). Specifically, firms sustain collusion as follows:

i if a firm deviates from the collusive agreement in period τ, then in period $\tau+1$ all firms enforce the punishment code. If

[7] In our baseline model, collusive firms serve only their own turf because of a joint profit maximization. However, we prove in Section 5.2 that this is not the case when firms have imperfect information about their own turf. Collusive firms maximize their joint profits by also serving the rival's turf and collusion is more likely to be sustained under unshared information.

[8] In a covered market with unit demand functions welfare is constant.

[9] In this section, we are assuming that the firms try to collude on joint-profits maximizing prices (perfect collusion). However, as we will show later in Section 5.1, the result in Proposition 1 extends also to the case of imperfect collusion, that is when collusion is maintained at less-than-maximum prices.

[10] In Section 5.2, we show that sharing information never facilitates the sustainability of a tacit agreement, but making the market more or less transparent when firms have imperfect information makes collusion more or less likely to be sustained according to the reservation price v.

all firms obey the punishment code, they return to collusion for the rest of the game;

ii if a firm deviates during the punishment phase in period τ, in period $\tau+1$ there is another round of punishment. If all firms obey the punishment code in $\tau+1$, they return to collusion in period $\tau+2$ and for the rest of the game. Otherwise, the punishment phase continues.

The punishment is optimal if it shrinks the present discounted value of profits after a deviation. Following Abreu (1986 and 1988), this requires that firms charge a price below the marginal cost and earn negative profits in the periods after a deviation. Specifically, in our framework, firms charge a uniform punishment price p_j^{OP} such that each firm j serves the consumers belonging to its own turf T_j and $\pi^{OP} = \int_{T_j} p_j^{OP}(z)\rho(z)dz = -\frac{\delta}{1-\delta}\pi^C$. Hence, the price is chosen in such a way that the present discounted value during the punishment phase, which we denote with V^{OP}, equals zero.

For simplicity, let us consider the case in which $p_j^{OP} < t(z_{-j}, z) - t(z_j, z) - c$. This implies that a firm deviating from the punishment path cannot do better than charging a price equal to -c,[11] which leads to $\pi^{DP} = 0$, regardless the information is shared or not with the rival.

Collusion is sustained if all firms have no incentive to deviate both from the collusive and the punishment phase. This means that the following incentive constraints – which we denote with IC – must hold:

$$\frac{\pi^C}{1-\delta} \geq \pi^D + V^{OP} \text{ (IC collusion)}$$

$$V^{OP} \geq \pi^{DP} + \delta V^{OP} \text{ (IC punishment)}$$

where π^D is a generic deviation profit, which varies between shared and unshared information regimes. Firms don't deviate from collusion if the above conditions are jointly satisfied. Since $\pi^{DP} = 0$, firms never have incentive to deviate from the punishment path and the IC for punishment is always satisfied. Instead, the IC for collusion is satisfied as long as the long-term profits from colluding are larger than the short-term gains from cheating, i.e.,

$$\delta \geq \frac{\pi^D - \pi^C}{\pi^D} \tag{3}$$

With the same logic adopted in the baseline model with grim trigger strategy, we can easily notice that firms' profits might differ between shared and unshared information regimes only in the case of deviation. Specifically, deviation profits in the case of unshared information cannot be larger than the deviation profits under shared information, so confirming our results in the baseline model.

4.2. Application: the hotelling model

In this section, we provide an example based on the Hotelling (1929) linear model. Consider a segment ranging from 0 to 1. Firm A is located at 0, whereas Firm B is located at 1. Consumers are distributed uniformly along the segment. Let $z \in [0,1]$ indicate the consumer location in the segment. Transportation costs are assumed to be linear: they are z when the consumer buys from Firm A, and $1-z$ when he buys from B. Therefore, the turf of Firm A is $T_A \equiv \{z : z \leq 1/2\}$, and that of Firm B is $T_B \equiv \{z : z \geq 1/2\}$. We assume that $v \geq 1$ to guarantee market coverage in any possible situation.

If firms adopt a grim trigger strategy, given (2), the equilibrium punishment prices are $p_A^P(z) = \begin{cases} 1-2z \text{ } if \text{ } z \in T_A \\ 0 \text{ } if \text{ } z \in T_B \end{cases}$, and $p_B^P(z) = \begin{cases} 0 \text{ } if \text{ } z \in T_A \\ 2z-1 \text{ } if \text{ } z \in T_B \end{cases}$, so that Firm A (B) serves consumers $z \leq (\geq) 1/2$ in equilibrium. Since each firm serves its own turf, the punishment profits, $\pi^P = 1/4$, are the same under shared and unshared information.

Now, consider the collusive phase. The collusive profits are maximized when each firm serves its own turf, so that Firm A serves the consumers $z \leq 1/2$ and Firm B serves the consumers $z \geq 1/2$, by adopting the following optimal collusive prices: $p_A^C(z) = v - z$ and $p_B^C(z) = v - (1-z)$, respectively. It follows that the collusive profits, $\pi^C = (4v-1)/8$, are invariant with the information regime.

Finally, we consider the deviation phase. Suppose that Firm A deviates, whereas Firm B does not. Under shared information, Firm A's deviation price schedule is: $p_A^D(z) = p_A^C(z)$, $\forall z$. The deviation profits are therefore $\hat{\pi}^D = \int_0^1 p_A^C(z)dz = v - \frac{1}{2}$. Consequently, the critical discount factor is $\hat{\delta}^* = 1/2$. Next, consider unshared information. In this case, Firm A must set a uniform price, $\tilde{p}_A$, on the consumers in Turf B. The furthest consumer served by Firm A, $\bar{z}$, is then obtained by equating the utility of the consumer when buying from Firm B at the collusive price and when buying from Firm A at the (uniform) deviation price, that is: $v - \tilde{p}_A - \bar{z} = v - p_B^C(\bar{z}) - (1-\bar{z})$, or $\bar{z} = v - \tilde{p}_A$, under the constraint that $\bar{z} \leq 1$. Therefore, Firm A maximizes $\tilde{p}_A(\bar{z} - 1/2)$ subject to $\bar{z} \leq 1$, yielding $\tilde{p}_A^D = \begin{cases} (2v-1)/4 \text{ } if \text{ } v \in [1, 3/2] \\ v-1 \text{ } if \text{ } v \geq 3/2 \end{cases}$ and $\pi^D = \begin{cases} (4v^2+4v-1)/16 \text{ } if \text{ } v \in [1, 3/2] \\ v - 5/8 \text{ } if \text{ } v \geq 3/2 \end{cases}$. Hence, the critical discount factor is $\breve{\delta}^* = \begin{cases} (2v-1)^2/(4v^2+4v-5) \text{ } if \text{ } v \in [1, 3/2] \\ 4(v-1)/(8v-7) \text{ } if \text{ } v \geq 3/2 \end{cases}$. It is immediate to observe that, in this example, $\hat{\delta}^* > \breve{\delta}^*$. Therefore, information sharing between the firms reduces collusion sustainability under price discrimination.

The same result holds if we consider an optimal punishment à la Abreu (1986 and 1988) as described in the previous section. In that case, the equilibrium punishment prices are given by $\pi^{OP} = \int_{T_j} p_j^{OP}(z)\rho(z)dz = -\frac{\delta}{1-\delta}\pi^C$, which leads to $p_j^{OP} = \frac{\delta}{1-\delta}\frac{1-4v}{4}$. Hence, the optimal punishment profits are $\pi^{OP} = \frac{\delta}{1-\delta}\frac{1-4v}{8}$ and the present discounted value during the punishment phase is $V^{OP} = 0$.[12] Adopting this punishment code allows firms to sustain collusion if (3) holds, i.e., $\delta \geq \frac{4v-3}{4(2v-1)}$ under shared information[13] and $\delta \geq \begin{cases} (2v-1)^2/(4v^2+4v-1) \text{ } if \text{ } v \in [1, 3/2] \\ 4(v-1)/(8v-5) \text{ } if \text{ } v \geq 3/2 \end{cases}$ if firms don't share their information. It is easy to verify that the former condition is more stringent than the latter, which means that sharing information cannot facilitate collusion.

5. Extensions

Building on the results obtained in the previous sections, now we provide some extensions of the model to account for degrees of imperfections in colluding and gathering consumer's personal data that we have neglected so far. The final aim is to provide an analysis of collusion and information sharing in a more complex context in which firms might partially collude or they have imperfect information about their past consumers. This allows considering the

[11] Recall that we are considering prices net of marginal costs.

[12] As in the previous section, we assume that $p_j^{OP} < t(z_{-j}, z) - t(z_j, z) - c$, which implies that $\delta > 4(c-1)/(4c+4v-5)$.

[13] Notice that, with optimal punishment, the critical discount factor becomes smaller than 1/2.

possibility that the exchange of information improves the degree of information accuracy.

5.1. Imperfect collusion

Up to now we consider the case of perfect collusion, where the firms fix collusively the prices to replicate the monopolistic profits. However, when perfect collusion is not sustainable in equilibrium (since the discount factor is too low), firms might try to collude on sub-optimal prices if these allow reaching a sustainable collusive agreement. Clearly, a necessary condition for imperfect collusion to be observed in equilibrium is that the critical discount factor must be lower under imperfect collusion than under perfect collusion. If this is the case, then the set of discount factors sustaining collusion in equilibrium is larger under imperfect collusion than under perfect collusion: that is, imperfect collusion could be used to reach an agreement that could not been sustainable otherwise. At the opposite, when the critical discount factor is larger or equal under imperfect collusion, there is no reason for imperfect collusion. In what follows, we show that, in the case of shared information, the critical discount factor is equal to 1/2 both under perfect and imperfect collusion. This is sufficient to prove that the result in Proposition 1 extends also to the case of imperfect collusion.

Suppose that information is shared and consider a *generic* collusive discriminatory price schedule,[14] namely $\dot{p}_j^C(z)$, so that collusive profits are $\dot{\pi}_j^C(z) = \int_{T_j} \dot{p}_j^C(z)\rho(z)dz$. Now consider the deviation profits. The deviation prices coincide with the collusive prices in the own turf because each firm is setting the highest price attracting the consumer given the rival's price. Instead, in the rival's turf, the deviation prices are $\dot{p}_j^D(z) = \dot{p}_{-j}^C(z) + t(z_{-j}, z) - t(z_j, z)$ (see footnote 6). Therefore, the deviation profits under imperfect collusion are:

$$\begin{aligned}
\dot{\pi}^D &= \dot{\pi}^C + \int_{T_{-j}} \dot{p}_j^D(z)\rho(z)dz \\
&= \dot{\pi}^C + \int_{T_{-j}} \left[\dot{p}_{-j}^C(z) + t\left(z_{-j}, z\right) - t\left(z_j, z\right)\right]\rho(z)dz \\
&= 2\dot{\pi}^C + \pi^P \qquad (4)
\end{aligned}$$

By using (4) into (1), we observe that $\dot{\delta}^* = \frac{\dot{\pi}^D - \dot{\pi}^C}{\dot{\pi}^D - \pi^P} = \frac{2\dot{\pi}^C - \pi^P - \dot{\pi}^C}{2\dot{\pi}^C - \pi^P - \pi^P} = \frac{1}{2}$. Therefore, imperfect collusion does not allow improving collusion sustainability in the case of shared information (that is $\dot{\delta}^* = \hat{\delta}^*$).

Consider now the case of unshared information. Suppose first that imperfect collusion does not allow reducing the critical discount factor under unshared information: in this case, imperfect collusion never occurs, and Proposition 1 still applies. Next, suppose that imperfect collusion reduces the critical discount factor, which now becomes $\dot{\breve{\delta}}^* < \breve{\delta}^*$. Obviously, this implies that $\dot{\breve{\delta}}^* < \dot{\delta}^*$. Therefore, sharing information makes collusion less sustainable even in the case of imperfect collusion. Furthermore, since $\dot{\breve{\delta}}^* < \breve{\delta}^*$ and $\dot{\delta}^* = \hat{\delta}^*$, the anti-collusive impact of sharing information is stronger under imperfect collusion than under perfect collusion.

Interestingly, the above result can be related with other papers discussing the impact of imperfect collusion in a spatial setup. For instance, Chang (1991) considers a simple linear Hotelling model with uniform pricing firms which are exogenously located in the segment. He shows that when perfect collusion is not sustainable in equilibrium, then firms might find it convenient to collude on a less-than-monopolistic uniform price, which is decreasing in the degree of product substitutability. Häckner (1995) extends Chang, (1991) to the case of endogenous locations while remaining in the Hotelling model, and he shows that when the discount factor is very low, the two firms locate at the endpoints and collude on a price which is lower than the monopoly price. Hence, even in Häckner (1995) imperfect collusion makes collusion easier to sustain. Colombo (2010) considers instead the possibility that both firms can perfectly price discriminate all over the Hotelling segment, and he shows that imperfect collusion does not lower the critical discount factor both when the firms collude on a (first-degree) discriminatory price schedule, nor when they collude on a uniform price. Then, our findings are similar to those in Colombo (2010), but they are obtained in a generalized spatial framework when firms might share information about consumers' preferences or not.

5.2. Endogenous information sharing

In this section, we make information sharing endogenous. This implies that firms decide whether to share their information with the rival or not. Since firms do not make use of information about the consumers belonging to the rival's turf both under punishment and collusion, introducing endogenous information sharing in our baseline model would not change the previous results. Hence, we propose an extension of the baseline model in which firms have less than perfect information on their own turf and some small information about the rival's turf. Specifically, we assume that each firm j knows whether a consumer belongs to its own turf or not but, differently from the baseline model, each firm j knows the precise location of a quota $\alpha \in [\frac{1}{2}, 1]$ of the consumers in T_j and a quota $1 - \alpha$ of the consumers in T_{-j}.[15] We denote with I_j the group of consumers whose location is perfectly known by firm j. When firms share their information with the rival, both firms know the exact location of each consumer in the market, otherwise they have imperfect information with a better knowledge of consumers belonging to their own turf.[16] As in the baseline model, each firm can price discriminate by setting a personalized price, $p_j(z)$, which is function of the consumer's location, for each consumer it has information about and they can set a different price for those consumers belonging to their turf (which is uniform for those consumers they have no information about).

Before starting the dynamic game, firms jointly commit to an information regime in which information is shared or unshared.[17] This choice can be viewed as a firms' lobby activity towards a Public Authority that can make the market more or less transparent through privacy rules and regulations. Alternatively, firms might choose to share their information by means of a database, maintained by a third-party firm, that collects all the information about

[14] We continue to assume the reasonable market sharing condition such that each firm serves the consumers belonging to its own turf.

[15] As in Colombo and Pignataro (2022), α can be interpreted as the degree of information accuracy. However, in contrast with their model, here firms have some information also about the rival's turf. This allows us to consider the case in which sharing information improves the degree of information accuracy about the consumers' data. We thank the editor and a referee for this insightful suggestion.

[16] We assume that $\alpha \geq 1/2$ as firms are more likely to get a better knowledge of consumers belonging to their own turf rather than those belonging to rival's turf.

[17] We also consider an alternative repeated game in which firms quote prices and decide simultaneously whether to share their information or not in every single period. This would greatly simplify our model: firms share their information only if they are colluding. Therefore, a marginal increase in α has an impact only on punishment profits that, as we show later, are increasing in α and approach the competitive profits when firms share their information as α goes to 1. This implies that the critical discount factor is increasing in α and lower than 1/2, making collusion easier to sustain when the information sharing decision is endogenous with respect to the exogenous case when firms share their information. Instead, it can be shown (details are available upon request) that jointly committing not to share information makes collusion easier to sustain. This suggests that firms may have a collective interest in pre-committing to an unshared information regime before competing in prices.

consumers' location.[18] Then, firms post prices, so deciding whether to participate in the collusive agreement. Therefore, the cooperative decision about the information regime determines whether collusion arises in equilibrium. For the sake of simplicity, let us consider the Hotelling model described in Section 4.2 by assuming that firms adopt a grim trigger strategy. In the following, we characterize the equilibrium outcomes under the assumption that firms join a regime in which information is unshared. Indeed, if firms decide to share their information, the model boils down to the equilibrium outcomes described in Section 4.2 when the location of consumers is common knowledge. Then, we compare the results under shared and unshared information, and we verify in which regime collusion is more likely to be sustained.

5.2.1. Unshared information

Suppose that firms don't share their information. Thus, we need to specify which turf T_j and information set I_j consumers belong to. We first derive the equilibrium profits of the stage game which will characterize the punishment phase after any deviation from the collusive agreement. Let us consider consumers belonging to Firm A's turf. If consumers belong to the information set of Firm A, Firm B sets a price $p_B(z \in I_A \cap T_A) = 0$, while the Firm A's best-reply function is given by $p_A(z \in I_A \cap T_A) = 1 - 2z$. Otherwise – i.e., $z \in I_B \cap T_A$ – Firm B sets a personalized price such that $v - p_A - z = v - p_B - (1 - z)$, which leads to $p_B = p_A + 2z - 1$. Hence, the further consumer served by Firm A is obtained by $\hat{z} = \frac{1-p_A}{2}$; a standard maximization problem and a system of equations lead to the following equilibrium prices: $p_A(z \in I_B \cap T_A) = \frac{1}{2}$ and $p_B(z \in I_B \cap T_A) = max\{2z - \frac{1}{2}; 0\}$.

Now, let us consider consumers belonging to Firm B's turf. By symmetry with the case analysed above, if consumers belong to the Firm B's information set, Firm A sets a price $p_A(z \in I_B \cap T_B) = 0$, while Firm B's best-reply function is given by $p_B(z \in I_B \cap T_B) = 2z - 1$. Instead, if $z \in I_A \cap T_B$, Firm A sets a personalized price $p_A = p_B + 1 - 2z$ and the further consumer served by Firm A is obtained by $\breve{z} = \frac{1+p_B}{2}$. It follows that the equilibrium prices are: $p_A(z \in I_A \cap T_B) = max\{\frac{3}{2} - 2z; 0\}$ and $p_B(z \in I_A \cap T_B) = \frac{1}{2}$.

It is worth noting that, if Firm j knows the exact location of consumers who belong to Firm -j's turf, it has a competitive advantage with respect to the rival that leads it to poach some consumers $z \in I_j \cap T_{-j}$. Specifically, given the uniform price set by the rival, Firm j charges a personalized (non-negative) price to each recognized consumer belonging to Firm -j's turf. If the transportation costs differential is too high with respect to the rival's uniform price, Firm j sets a price equal to zero.

The firms' punishment profit functions can be written as follows:

$$\pi_A^P = \alpha \int_0^{\frac{1}{2}} (1-2z)dz + (1-\alpha)\left[\int_0^{\breve{z}} \frac{1}{2}dz + \underbrace{\int_{\frac{1}{2}}^{\breve{z}} \left(\frac{3}{2} - 2z\right)dz}_{poaching\ \ profits}\right]$$

$$\pi_B^P = \alpha \int_{\frac{1}{2}}^{1} (2z-1)dz + (1-\alpha)\left[\underbrace{\int_{\hat{z}}^{\frac{1}{2}} \left(2z - \frac{1}{2}\right)dz}_{poaching\ \ profits} + \int_{\breve{z}}^{1} \frac{1}{2}dz\right]$$

Therefore, the symmetric equilibrium punishment profits are:

$$\pi_j^P = \frac{3+\alpha}{16}, \quad j = A, B$$

Suppose, instead, that firms collude and maximize their joint profits without sharing their information. Now, firms have two candidate collusive strategies. As in the baseline model, they can share the market equally by serving only their own turf (but quoting a personalized price for the consumers belonging to their own information set and a uniform price for the rest of the turf). Alternatively, they can adopt a collusive strategy, that we denote as "poaching in collusion", according to which each firm j serves: (i) all the consumers $z \in I_j \cap T_j$ with a personalized price; (ii) a fraction, which we denote with $\tilde{z}$, of the consumers $z \in I_{-j} \cap T_j$ with a uniform price; (iii) a fraction $1 - \tilde{z}$ of the consumers $z \in I_{-j} \cap T_j$ with a personalized price. In the Online Appendix, we show that firms maximize their joint profits if they use a "poaching in collusion" strategy. This implies that charging a personalized price for distant but identified consumers is more profitable than charging a uniform price to closer but unidentified consumers. In other words, getting information about consumers is more valuable than being closer to them.

Let us characterize the collusive prices for Firm A.[19] Firm A extracts the entire surplus from group (i) by charging a personalized price $p_A(z \in I_A \cap T_A) = v - z$. Instead, the last consumer from group (ii) served by Firm A in its turf is given by $v - p_A(z \in I_B \cap T_A) - \tilde{z} = 0$, where $p_A(z \in I_B \cap T_A)$ is a uniform price. Finally, the personalized price for the group of consumers (iii) is given by $v - p_A(z \in I_A \cap T_B) - z = 0$, i.e., $p_A(z \in I_A \cap T_B) = v - z$. Hence, the profit function can be written as follows:

$$\pi_A^C = \alpha \int_0^{\frac{1}{2}} (v-z)dz + (1-\alpha) \times \left[\int_0^{\tilde{z}} p_A(z \in I_B \cap T_A)dz + \underbrace{\int_{\frac{1}{2}}^{1-\tilde{z}} (v-z)dz}_{collusive\ \ poaching\ \ profits}\right]$$

Differentiating the above equation with respect to the uniform price $p_A(z \in I_B \cap T_A)$ yields the following optimal collusive price $p_A(z \in I_B \cap T_A) = v - \frac{1}{3}$, which always satisfies the condition $\tilde{z} \in [0, \frac{1}{2}]$. Hence, the symmetric collusive profit if firms adopt such a "poaching in collusion" strategy is equal to

$$\pi_j^C = \frac{v}{2} - \frac{5-2\alpha}{24}, \quad j = A, B$$

Finally, we consider the deviation phase. Let us suppose that Firm A deviates from the collusive agreement. As in the baseline model, it cannot do better than charging the collusive price schedule to the consumers belonging to its turf[20] and the following deviation prices for the consumers belonging to the Firm B's turf:[21]

$$p_A = \begin{cases} v + \frac{2}{3} - 2z \ if \ z \in I_A \cap T_B \\ \frac{1}{4}(2v-1) \ if \ z \in I_B \cap T_B \end{cases}$$

[18] This interpretation of the model recalls the Italian antitrust case I575 - Ras-Generali/Iama Consulting. In that case, the Italian Antitrust Authority (AGCM) identified an anti-competitive conduct in the exchange of business information between insurance companies through a database managed by a third-party company. AGCM believed that the exchange of sensitive information allowed insurance companies to predict with sufficient accuracy the future offerings of their competitors.

[19] The argument is symmetric for Firm B, as the information sets are symmetric as well.

[20] However, in this framework, collusive firms don't serve their entire turf, but a part of it, including all the identified consumers and some unidentified consumers, and a small quota of the rival's turf which is decreasing in α. Hence, if a deviating firm continues charging the collusive price schedule to the consumers belonging to its own turf, in contrast with the baseline model, it is not serving its entire turf.

[21] For the sake of simplicity, we assume that v is sufficiently large such that deviating from collusion allows Firm A to poach all the consumers belonging to the Firm B's turf.

As intuition suggests, if Firm A has some information about the consumers belonging to the Firm B's turf, it can use it to charge personalized prices. Otherwise, it sets a uniform deviation price with a standard undercutting logic.

The Firm As' deviation profit function can be written as follows:

$$\pi_A^D = \underbrace{\alpha \int_0^{\frac{1}{2}} (v-z)dz + (1-\alpha)\int_0^{\tilde{z}} \left(v-\frac{1}{3}\right)dz}_{\text{collusive profits from firm A's turf}} + \underbrace{\alpha \int_{\frac{1}{2}}^{1} (2v-1)dz + (1-\alpha)\int_{\frac{1}{2}}^{1} \left(v+\frac{2}{3}-2z\right)dz}_{\text{deviating poaching profits}}$$

which leads to

$$\pi_A^D = \frac{3v(10-\alpha)-19+10\alpha}{36}$$

It is worth noting that deviating from the collusive agreement allows Firm A (or Firm B by symmetry) to keep the collusive profits from consumers belonging to its turf and to poach the consumers belonging to the rival's turf. Therefore, the collusive poaching profits are replaced by the larger deviating poaching profits.

Hence, by using (1), the critical discount factor is

$$\tilde{\delta}^* = \frac{46-28\alpha+12v(\alpha-4)}{103-31\alpha+12v(\alpha-10)}$$

5.2.2. Comparative statics

Now, let us compare the results obtained under the assumption that firms don't share their information with those characterize in Section 4.2 when firms can recognize the location of all the consumers distributed along the Hotelling line, which correspond with the case in which information is shared. In the relevant region of parameters – i.e., if v is sufficiently large – we observe that $\tilde{\delta}^*$ is non-monotonic in α and $\tilde{\delta}^* < \frac{1}{2}$. This leads to the following result.

Proposition 3. *If firms have imperfect and complementary information about consumers, collusion is more difficult to sustain if firms share their information for any $\alpha \in [\frac{1}{2}, 1]$. There exists also a threshold $\hat{v}$ such that the critical discount factor $\tilde{\delta}^*$ is increasing in α if $v \leq \hat{v}$ and decreasing otherwise.*

Proof. See the Online Appendix.

The result in Proposition 3 is twofold. If firms have less than perfect information about consumers belonging to their own turf, collusion is easier to sustain if firms don't share their information. Hence, sharing information never facilitate collusion, so confirming our results in the baseline model.[22] Moreover, if the reservation price v is not too large, collusion becomes more difficult to sustain as the precision of the information about their own turf increases (the contrary holds for the precision of consumers belonging to the rival's turf). This implies that an increase in α, which allows firms to focus on their own turf rather than rival's one, reduces the difference in terms of collusion sustainability between unshared and shared information regimes. Indeed, a better knowledge of their own turf allows firms to extract more surplus from the closer consumers, so increasing profits both in the punishment and in the collusive phase. It also shrinks the poaching profits as each firm can attract consumers belonging to the rival's turf mainly through a uniform rather than a personalized price. This is why the deviation profits are non-monotonic in α and, specifically, they are increasing in α only if the reservation price v is not too large. Hence, if the reservation price v is sufficiently small, the combination of the effects of α on the punishment profits (positive) and on the deviation profits (negative) overwhelms the positive impact on the collusive profits, so increasing the critical discount factor.

The relationship between α and $\tilde{\delta}^*$ echoes the results of Colombo and Pignataro (2022) when v is sufficiently large. In this case, collusion becomes more difficult to sustain as the information technology gets close to be perfect. However, in our model, an increase in α allows each firm to have a better understanding of its own turf, while in Colombo and Pignataro (2022) an increase in α allows each firm to identify a larger quota of its own consumers at each point of the market. Moreover, we consider a first-degree price discrimination, while they study a history-based price discrimination according to which firms charge different prices to consumers depending on whether or not they belong to the inherited market share. These differences in the modelling assumptions lead to a different result when v is not too large. Indeed, in our paper, the relationship between α and $\tilde{\delta}^*$ is hump shaped, while it is U-shaped in Colombo and Pignataro (2022). That said, we share with them two relevant results: (i) poaching in collusion is the most profitable strategy when firms can price discriminate; (ii) a complete market transparency or the exchange of information about consumers might hinder collusion.[23]

The above results have important policy implications for Antitrust and Public Authorities aiming at hindering collusion. Although it is not possible to enforce a policy intervention that makes information sharing mandatory, collusion can be hampered, for instance, by making the market more transparent – i.e., by setting privacy rules and regulation that allow firms to easily collect and analyse a vast set of consumers' data. Alternatively, according to the value of the reservation price v, Antitrust and Public Authorities can manage the information that firms can collect about their own and rival's consumers to make collusion more difficult to sustain. In practice, regulating the use of algorithms, machine learning, and data-mining processes can make the information gathering process more or less difficult to implement, in particular for those consumers whose location is far in terms of geography or preferred variety.

Finally, we conclude this section by comparing the punishment and collusive profits under shared and unshared information. Our aim is to characterize the information regime that maximizes the consumer surplus.[24] Of course, in practice, firms may decide to adopt different pricing scheme and to use the acquired information to welfare enhancing initiatives. For example, sharing information could allow firms to make tailored offers, in terms of products and advertisement, and personalized discounts based on the consumers' preferences (see e.g., Anderson et al., 2022). We don't consider these side efficient effects, but they should be certainly considered by Antitrust and Public Authorities. This leads to the following proposition.

Proposition 4. *For $\delta \in [\tilde{\delta}^*, \frac{1}{2})$ consumer surplus is maximized by a policy that forces firms to share their information. Otherwise, the optimal policy is to forbid information sharing.*

[22] We show in the Online Appendix that this result holds even if firms collude through a simple but suboptimal strategy – i.e., they don't adopt a "poaching in collusion" strategy, but they simply serve their own turf.

[23] Similar results have also been obtained by Liu and Serfes (2007), Sugaya and Wolitzky (2018) and Miklós-Thal and Tucker (2019). They find that more precise knowledge of consumers' willingness to pay has a negative impact on collusion sustainability.

[24] Since the decision to share information or not is endogenous, firms share their information only if it doesn't affect the sustainability of a tacit agreement (i.e., if collusion is always or never enforceable). Therefore, in this context, the optimal policy takes into account both the (dynamic) effect on collusion sustainability and the (static) effect on consumer surplus.

We have already argued that information sharing makes collusion more difficult to sustain. Hence, if the discount factor is intermediate, such that collusion is self-enforceable if and only if firms don't share their information, a policy intervention that makes the market more transparent is optimal for consumers. Instead, if the discount factor is sufficiently low, such that collusion is unviable regardless the information regime – i.e., $\delta < \tilde{\delta}^*$ – forcing firms to share their information would be harmful to consumers. Indeed, it would convey a certain market power to the firms toward the closest group of consumers, so extracting a larger surplus from consumers. Forbidding sharing information is also optimal if the discount factor is sufficiently high, such that collusion is always enforceable – i.e., $\delta \geq \frac{1}{2}$. In that case, any policy intervention cannot affect the sustainability of collusion but only the reduction of surplus extraction. When information sharing is viable, firms have a monopolistic power toward their own entire turf, which leads them to get collusive profits which are larger than under unshared information. In sum, from the perspective of consumers, encouraging information sharing is ideal only if collusion is *de facto* a risk. This provides a novel rationale for the antitrust law which currently looks at the exchange of information across firms with suspicion.

Concluding remarks

In this paper, we contribute to the literature studying the relationship between information sharing and collusion sustainability. We focus on the exchange of information about the consumers' preferences by providing a general model in which firms may charge personalized prices to the consumers they have information about. We argue that information sharing never facilitates tacit collusion when price discrimination is viable. This result can be explained through the increasing effect of sharing information on deviation profits, while punishment and collusive profits are unaffected. Although there may exist other reasons explaining why firms communicate to each other – e.g., to create an explicit cartel – one takeaway of our analysis is that Antitrust Authorities should enforce a careful investigation before concluding that sharing information about consumers is necessary to sustain collusion. Although a ban on information sharing could protect consumers from surplus extraction when firms have imperfect information about their own consumers, even in this case, collusion is more likely to be sustained under unshared rather than shared information regimes. Hence, we can conclude that a policy intervention that forbids information sharing could have the unintended effect of facilitating the sustainability of a tacit agreement. Our findings, which are robust to imperfect collusion and imperfect information, shed some doubts on the common wisdom according to which firms exchanging information are more likely to collude.

Declaration of Competing Interest

None.

Data availability

No data was used for the research described in the article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.infoecopol.2023.101032.

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