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Customer-side transparency, elastic demand, and tacit collusion under differentiation ☆

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ABSTRACT

Customer-side price transparency affects sustainability of collusion in a duopoly model of spatial product differentiation with elastic demand. When product differentiation is significant, more transparency facilitates collusion as measured by the critical discount factor. For the case where products are relatively homogeneous, the relationship is U-shaped. The level of transparency that optimally deters collusion is thus zero for intermediate to large degrees of product differentiation. Only when products are very moderately differentiated will full transparency be beneficial.

1. Introduction

The question of whether ensuring that customers are better informed results in more competitive market outcomes is of great importance for both competition authorities and consumer protection agencies. Practitioners seem to consider an increased market transparency on the customer side as an appropriate means to promote competition. For example, the Bundeskartellamt (German Competition Authority) emphasizes the unambiguously positive effects of a higher degree of customer information on competition.[1] In the same vein, it is often argued that the undesirable consequences of coordinated behavior stemming from an increased transparency among firms may be alleviated if customers gain access to more information at the same time. As Capobianco and Fratta (2005) report, the Autorità Garante per la Concorrenza ed il Mercato (Italian Competition Authority) holds the opinion that a higher elasticity of demand in a situation where customers are better informed “may, in a dynamic context, undermine any potential collusive practice” (p. 6) resulting from the exchange of information between firms.

In this article, we build on Schultz (2005) who sets up a Hotelling (1929) model with inelastic demand to analyze the implications of customer-side price transparency for

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[1] See, e.g., “Bundeskartellamt veröffentlicht bundesweiten Gaspreisvergleich für Haushaltskunden [German Competition Authority publishes countrywide gas-price comparison for households]”, press release, January 3, 2007 (document available from www.bundeskartellamt.de).

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the stability of tacit collusion. Generally speaking, increasing transparency has two opposing effects on the stability of collusion: on the one hand, deviation from the collusive outcome becomes more attractive as more customers learn about price cuts. On the other hand, there is tougher price competition if collusion breaks down, i.e., the potential punishment is harsher. He shows that a higher degree of transparency unambiguously destabilizes collusion.[2] Contrary to that, we find that increased customer transparency may not necessarily be the optimal solution to fight anticompetitive behavior. Our setup differs from his approach in that we set up a model of spatial competition where two horizontally differentiated firms face customers with elastic (heterogeneous) demand. Applying the concept of grim-trigger strategies, we show that for a relatively low degree of differentiation, the implications of an increase in market transparency are ambiguous and increasing transparency may be desirable in order to destabilize collusion. If, however, the degree of differentiation is sufficiently high, a greater market transparency—different from the inelastic-demand case—stabilizes collusion.

The reason behind this difference is that, with elastic demand, a change in the level of differentiation has an additional effect compared to the case with inelastic demand: beside a competition effect which leads to higher (competitive) prices as firms become more differentiated and which is also present in the inelastic-demand case, there is a (price) elasticity effect.[3] This price-reducing effect refers to the observation that customers' demand is lower, the higher the price and/or the greater the distance between the product's characteristics and their preferences. The competition effect dominates the elasticity effect for low and moderate levels of differentiation. Thus, the situations with elastic and inelastic demand are not different when it comes to the impact of differentiation on collusive stability. However, the elasticity effect dominates the competition effect if firms are highly differentiated. In this case, a deviating firm which needs to undercut its rival not only gains a larger market share from its competitor but also faces a higher local demand which comes as an additional benefit. As a consequence, deviation becomes more attractive. Moreover, the elasticity effect gains in importance as firms become more differentiated and thus, collusion is destabilized when the degree of differentiation increases.

As for the change in transparency, its impact on collusive stability is similar to a change in differentiation. Consider the situation where firms are very differentiated, i.e., the elasticity effect dominates. If transparency increases, a larger number of customers compares the prices set by the two firms which results in more intense competition such that the elasticity effect becomes less important. This is the same effect stemming from a decrease in differentiation and hence, collusion is stabilized.

If the degree of differentiation is low and if the market is rather transparent already, then a further increase in market transparency yields the same outcome compared to a decrease in differentiation when firms are close substitutes: collusive stability is reduced due to the predominant competition effect. The opposite holds for an almost completely opaque market: even though firms are close substitutes, there is hardly any competition as customers are not aware of firms' prices which means that the elasticity effect dominates. Increasing market transparency then has the same effect compared to the case where, starting from a high level of differentiation, differentiation is reduced: collusion is stabilized.

Beside the contribution by Schultz (2005), there are only a few other contributions that analyze the implications of different levels of market transparency on the customer side.[4]

A very different approach to dealing with customer-side transparency is suggested by Nilsson (1999). He develops a model with unit demand and homogeneous products. In his model, the majority of customers account for the expected benefits from searching and decide whether to search or not on that basis. Contrary to that, a fraction of the customers always search. A higher degree of transparency here translates into lower search costs. Most customers thus no longer search if firms set the same price which is true for the (high-price) collusive phase. As a consequence, deviation leads to a moderate increase in demand only which stabilizes the collusive agreement. In the punishment phase of the collusive equilibrium, firms set different (mixed-strategy) prices which means that the majority of customers do search. Clearly, if transparency increases, there will be more search activity and hence tougher competition. Since an increase in transparency only affects the punishment profits, it helps stabilize the collusive agreement.

Møllgaard and Overgaard (2001) define market transparency as customers' ability to compare the products' characteristics or quality. Products are actually homogeneous but are perceived as differentiated due to a lack of rationality on the customer side. The authors show that for the case of trigger strategies, the optimal degree of transparency to make collusion as difficult to sustain as possible is interior in the duopoly case. The implication of their analysis to maintain some degree of opaqueness in the market in order to make collusion harder to sustain contrasts with the results in the present model for the case of high differentiation.[5]

From an empirical point of view, Albæk et al. (1997) as well as Wachenheim and DeVuyst (2001) provide two studies where a policy mainly directed at improving customers' level of information resulted in higher prices.[6] The argument often put forward to explain this outcome is that by giving customers more information, firms learn about competitors' prices at the same time. This makes it

[2] See also Schultz (2009b).

[3] See Mérel and Sexton (2010).

[4] For an overview, see Møllgaard and Overgaard (2006) as well as Overgaard and Møllgaard (2008). Most articles deal with the implications of information exchange between firms for the stability of collusive agreements (see, e.g., Kühn and Vives, 1995; Kühn, 2001).

[5] Full transparency is shown to be optimal for five or more firms. Moreover, the authors find that full transparency is unambiguously optimal with two firms when applying optimal symmetric penal codes following Abreu (1986, 1988) and Abreu et al. (1986) (see also Møllgaard and Overgaard, 2002).

[6] Albæk et al. (1997) analyze the Danish market for concrete. Wachenheim and DeVuyst (2001) look at the US livestock and meat industries.

easier for firms to detect deviation and enact the punishment which in turn facilitates collusion.[7] The analysis in our setup where firms are fully informed about their competitor's price suggests a different—or complementary—explanation for the observation of increased prices: a higher degree of transparency on the customer side may have a direct stabilizing effect for collusion as well.

In their experimental study, Hong and Plott (1982) analyze the possible consequences of a proposed rate publication policy for the domestic barge industry on inland waterways in the United States. At the time of the experimental study, rates on tows were set through individual negotiations and the terms of each contract were private knowledge of the contracting parties only. Therefore, there were calls for a requirement that a carrier had to announce a rate change with the Interstate Commerce Commission (ICC) at least fifteen days before the new rate was to become effective.[8] The authors find that a publication policy resulted in higher prices, lower volume, and reduced efficiency in the laboratory. Moreover, the introduction of such a policy hurt the small participants.[9]

The article proceeds as follows. In Section 2, the model is introduced. We derive and analyze the critical discount factor in Section 3. Section 4 concludes. The derivation of profits as well as proofs are relegated to Appendix A.

2. Model

There are two firms which are located at the two extremes of the Hotelling (1929) line of unit length. Their marginal costs are normalized to zero. Both firms are fully informed about the price charged by the competitor. Customers of mass one are uniformly distributed along the line. To include different transparency levels, only a share α of the customers are assumed to be informed about the prices charged by the firms (where $\alpha \in (0,1]$). Firms' locations along the linear city are common knowledge to both customer groups. All customers either buy from firm 1 located at 0 or from firm 2 located at 1. Let q denote the quantity a customer demands at a given price and location. Then, a customer located at x derives the following utility

$$U_i(x,p_i) = \begin{cases} q - \frac{q^2}{2} - q(p_1 + \tau x) & \text{when buying from firm 1} \\ q - \frac{q^2}{2} - q(p_2 + \tau(1-x)) & \text{when buying from firm 2,} \end{cases} \tag{1}$$

where τ measures the degree of differentiation (transportation costs) and p_i denotes the price charged by firm i (with $i \in \{1,2\}$). Note that the way the utility is defined implies that a customer incurs the transportation costs for every unit purchased, i.e., transportation costs increase linearly in the number of products purchased. Alternatively, one may interpret τ as the disutility a customer faces when he buys a product that does not fully match his ideal product. Then, $q\tau x$ represents the total disutility suffered by a customer with preferred product characteristics of x when consuming a product that is not ideal. Note that the larger are q and/or x, the greater the disutility.

The way uninformed customers are modeled follows Varian (1980) and Schultz (2005): an uninformed customer does not know any of the two prices charged by the two firms[10]. Moreover, he has no opportunity to learn about firms' prices by visiting them sequentially, i.e., the possibility to search for a better price is excluded. Futhermore, uninformed customers do not learn across different periods which means they have to form beliefs about the prices set by the firms. Given their expectations, uninformed customers decide which firm to buy from. Beliefs are such that they are correct in equilibrium, i.e., uninformed buyers anticipate the prices set by the firms. To deal with out-of-equilibrium behavior, we assume that if buyers observe a price different than expected, they keep their belief about the price charged by the other firm.[11] As firms are symmetric (and in line with the literature cited above), in what follows, we will restrict our attention to symmetric equilibria where the expected prices charged by both firms are the same. As a result, uninformed customers always buy from the closest firm, i.e., the indifferent uninformed customer is located at 1/2.

As (informed) customers are assumed to be utility maximizers, the above utility specification implies that a customer located at x will buy the following quantity from firm 1

$$\max_q U_1(x,p_1) \Rightarrow \partial U_1/\partial q = 1 - q - p_1 - \tau x = 0$$
$$\iff q_1(x,p_1) = 1 - p_1 - \tau x.$$

Hence, a customer has the following local demands at either of the two firms

$$q_i(x,p_i) = \begin{cases} 1 - p_1 - \tau x & \text{when buying from firm 1} \\ 1 - p_2 - \tau(1-x) & \text{when buying from firm 2.} \end{cases} \tag{2}$$

As far as uninformed customers are concerned, we point out that their demand is also represented by expression (2). Given their beliefs regarding prices when buying from firm 1, they maximize expected utility of $\mathbb{E}U(q,p_1) = \mathbb{E}(q - q^2/2 - q(p_1 + q\tau x)) = q - q^2/2 - q(\mathbb{E}(p_1) + q\tau x)$, i.e., $\mathbb{E}U(q,p_1) = U(q,\mathbb{E}(p_1))$. As a consequence, we have $\partial \mathbb{E}U(q,p_1)/\partial q = \partial U(q,\mathbb{E}(p_1))/\partial q$. Given that uninformed customers have rational expectations, their demands are given by expression (2).

The utility specification implies that customers' homogeneity with respect to their product preferences is

[7] See Njoroge (2003) for the livestock and meat example. Contrary to that, Azzam (2003) as well as Azzam and Salvador (2004) find no evidence of collusion in these industries.

[8] Note that, just like in the empirical studies cited above, the publication requirement means that both customers as well as competitors have access to more information.

[9] Note that it is true that conversations on price collusion were strictly forbidden but clearly, there was room for tacit collusion.

[10] This approach is also used in Schultz (2004, 2009a,b) as well as Gu and Wenzel (2012).

[11] This implies that if a firm deviates with a lower price (out of equilibrium), those uninformed buyers who decided to buy from this firm are still willing do so.

also reflected in their individual demand which decreases as the difference in preferences and actual product characteristics grows.[12]

We make the following assumption:

Assumption 1. Transportation costs are such that competing firms always find it optimal to sell to both groups of customers, i.e., $\tau \geqslant 4(1-\alpha)(\alpha^2 - 3\alpha + 2\sqrt{\alpha^3 - 16\alpha^2 + 64\alpha})/(256 - \alpha^3 + 10\alpha^2 - 73\alpha) =: \underline{\tau}$, and the market is covered, i.e., $\tau \leqslant 4/3 =: \bar{\tau}$.

The assumption that the market is covered means that all customers along the line go to exactly one of the two firms, i.e., not buying at all is not optimal. However, as can be seen from expression (2), this is only true if transportation costs are not too high. We impose a lower bound on the transportation costs as we refrain from analyzing the situation where firms are (almost) homogeneous. In this case which requires the derivation of mixed strategies, Schultz (2005) shows for an inelastic demand that transparency has no (a vanishingly small) effect on the possibilities of tacit collusion. We conjecture that the same is true in the present setup and hence we will not study it further. Note that the lower bound first increases with α and then decreases; it is equal to zero both for $\alpha \to 0$ and $\alpha = 1$.[13] We will comment on the derivation of these bounds below.

Plugging the local demands specified in expression (2) into the respective utility expressions in (1) implies that the indifferent (informed) customer located at $\tilde{x}$ is given by

$$U_1(\tilde{x}, p_1) = U_2(\tilde{x}, p_2) \iff \tilde{x} = \frac{1}{2} - \frac{p_1 - p_2}{2\tau}.$$

We focus on the standard grim-trigger strategies defined by Friedman (1971). Thus, collusion is an equilibrium strategy when the discount factor δ exceeds the critical discount factor $\bar{\delta}$ given by

$$\delta \geqslant \bar{\delta} := \frac{\pi^D - \pi^C}{\pi^D - \pi^N} \qquad (3)$$

where π^C, π^D, and π^N denote collusive, deviation, and punishment profits. All things equal, a lower (higher) punishment or deviation profit leads to a stabilization (destabilization) of the collusive agreement whereas the opposite is true for a change in the collusive profit.

Let us briefly comment on the choice of grim-trigger strategies. Certainly, an alternative option would be the use of optimal punishments following Abreu (1986, 1988) and Abreu et al. (1986) (so-called stick-and-carrot strategies). In the context of a setup à la Hotelling (1929) with quadratic transportation costs and symmetric firms, Häckner (1996) shows that applying optimal punishments gives qualitatively the same results regarding the impact of product differentiation on the collusive price as with grim-trigger strategies analyzed in Chang (1991). Furthermore, our benchmark is the inelastic-demand case of Schultz (2005) who also applies grim-trigger strategies. Together with the finding in Häckner (1996), it thus appears reasonable that we restrict our attention to grim-trigger strategies.

In order to be able to determine collusive stability under different degrees of market transparency, we next need to derive the profits for the three cases of collusion, deviation, and punishment. We relegate this exercise to the appendix and proceed with the analysis of the critical discount factor.

3. Critical discount factor

Given the profits under collusion, deviation, and punishment, we obtain the following result concerning the critical discount factor for any combination of transparency and differentiation:

Proposition 1. *There exists a threshold of the differentiation parameter such that given differentiation is below this threshold, an increase in transparency stabilizes (destabilizes) collusion if the degree of transparency is low (high). If differentiation is above the relevant threshold, an increase in transparency always stabilizes collusion.*

Proof. See the Appendix A. □

Fig. 1 depicts the critical discount factor for the different parameter values of market transparency and product differentiation. Interestingly, an increase in market transparency always leads to a lower critical discount factor if the degree of differentiation is relatively high. For low and moderate levels of differentiation, the relationship is U-shaped.

To understand these results, we first have a closer look at the extreme cases, i.e., at those situations where firms are either hardly or very differentiated and where the market is either completely opaque or fully transparent.[14] We thus distinguish between the effects of changing the degree of differentiation or transparency in the market. As we argue below, changing the level of transparency has similar effects compared to changing the degree of differentiation. We start with an analysis of differentiation.

Consider the case with full transparency and a change in differentiation. Observe first that differentiation has two effects for (competing) firms facing an elastic demand (see the demand given by expression (4)). Following the taxonomy in Mérel and Sexton (2010), the first effect can

[12] The model is kept as simple as possible to capture product differentiation as well as elastic demand and to ensure the analysis is kept tractable at the same time. It would have been desirable to come up with a specification that embeds both cases with elastic and unit demand. However, such demand functions turned out to be intractable. The specification in Rothschild (1997) is similar to our limit case where $\alpha = 1$. Puu (2002) also uses a similar setup in the context of a price-then-location game. Gupta and Venkatu (2002) develop a model with horizontally differentiated firms, elastic demand, and fully informed customers to analyze the stability of collusion under quantity competition and delivered pricing (i.e., in a situation where firms bear the transportation costs). One could also think of a different approach where customers are homogeneous with respect to their demand, i.e., where their location does not have any impact on the elastic demand function. Recent examples for such a setup are the models by Gu and Wenzel (2009) as well as Mérel and Sexton (2010).

[13] Note that $\underline{\tau}$ attains a maximum of approximately 0.09125 for $\alpha \approx 0.33581$.

[14] The insights are summarized in Lemmas 1 and 2 and can be found in the appendix together with the proofs.

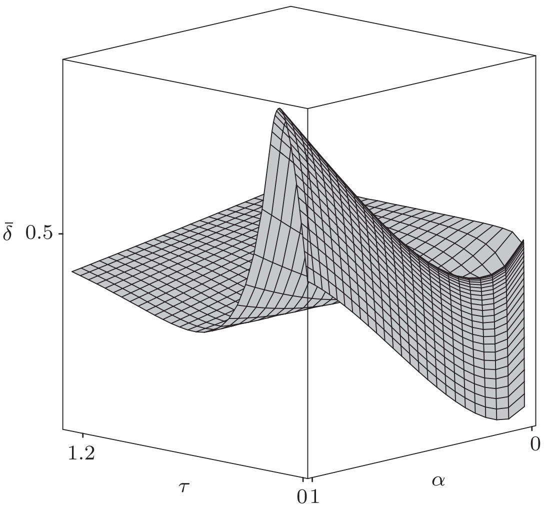

Fig. 1. Characterization of the critical discount factor $\bar{\delta}$ for different values of customer transparency α and differentiation τ.

be referred to as *competition effect* and gives firms an opportunity to set higher (competitive) prices due to market power as the degree of differentiation between firms increases. The second effect, called *(price) elasticity effect*, implies that each firm has an incentive to lower its (competitive) price to limit the reduction in local demand as firms become more differentiated. For low and moderate levels of differentiation, the competition effect dominates the elasticity effect which means that (competitive) prices increase in the level of differentiation. However, firms need to reduce prices once the level of differentiation is relatively high in order to boost local demand. As a result, an increase in differentiation first leads to higher (competitive) prices and profits before they begin to fall again. Note that importantly, the elasticity effect is not present in a model of inelastic demand (like the one in Schultz, 2005), i.e., prices always increase in the degree of differentiation (at least as long as the market is covered as assumed here).

When it comes to collusive stability, this observation implies that as long as the competition effect dominates, i.e., for low and moderate levels of differentiation, the impact of differentiation on collusive stability in the present situation is the same as in the inelastic-demand case: if firms are differentiated to a rather limited extent only, a deviating firm always serves the whole market which makes deviation very attractive and hence an increase in differentiation destabilizes collusion due to lower punishments (in the form of higher competitive profits). For moderate differentiation, a higher level of differentiation leads to a stabilization of the collusive agreement as attracting customers becomes harder and hence, deviation is not sufficiently attractive.[15]

Now if firms are very differentiated, the elasticity effect dominates the competition effect. Remember that a deviating firm has to undercut its competitor to gain market share. Now with elastic demand, a lower price not only results in a greater market share but also increases local demand from inframarginal customers and hence profits. This means that deviation becomes more profitable compared to the first case where the competition effect dominated. As the elasticity effect becomes more and more dominant as the level of differentiation rises, this additional benefit from deviation gains in importance. Therefore, collusion is destabilized with an increase in the degree of differentiation.[16] Contrary to that, with inelastic demand, only the competition effect is present and the same reasoning as with lower levels of differentiation still applies, i.e., collusion is stabilized as firms become more differentiated.

If the market is completely opaque, there is no benefit from deviating because no customer learns about the reduced (deviating) price. This reasoning is independent of the degree of differentiation between the two firms. As a consequence, differentiation has no impact on the critical discount factor.

As far as a change in transparency is concerned, we point out that its effect is similar to the implications a change in differentiation has for the competition effect. Consider first an increase in transparency for a (fixed) high level of differentiation: in this situation, giving more information to customers means that a larger number of them actually becomes aware of the prices set by the two firms which toughens competition—just like a decrease in differentiation increases the importance of the competition effect. Thus, collusion is stabilized.

Turning to an increase in market transparency for a (fixed) low degree of differentiation, we point out that if the market is rather transparent already, then a further increase in market transparency has the same effect as a decrease in differentiation in a situation where firms are close substitutes: collusion will be harder to sustain as the price effect dominates. The opposite is true for the case in which the market is close to being completely opaque: even though firms are close substitutes, the competition in the market is not very intense due to a lack of information on the customer side. As a result, customers behave as if firms were very differentiated, i.e., the elasticity effect dominates. Now if customers have access to more information, the elasticity effect loses in importance vis à vis the competition effect. Thus, we have the same effect as in a situation where, starting from a high level of differentiation, differentiation is reduced: collusion is easier to sustain. Put together, we obtain a U-shaped relationship between transparency and collusive stability.

Let us now consider the question when it is optimal to increase transparency in order to destabilize collusion. As the examples in the introduction highlight, competition authorities often argue in favor of a fully transparent market on the customer side as an effective means to destabilize potential collusive agreements. The following result gives an answer to the question whether or not this is optimal:

Proposition 2. *Full transparency (i.e., $\alpha = 1$) only results in the highest critical discount factor and hence least stable collusion if the degree of differentiation is low.*

[15] See, e.g., Chang (1991).

[16] See also Rothschild (1997).

Proof. See the Appendix A. □

Hence, a minimum of collusive stability is attained through a fully transparent market only if the degree of differentiation is sufficiently low. Due to the ambiguous impact of transparency on the critical discount factor for low levels of differentiation, increasing market transparency only partially may actually have detrimental effects for customers as firms may be enabled to charge higher (collusive) prices. Moreover, fostering full transparency on the customer side may also have just the opposite effect of what is intended: if the degree of differentiation is above the specified threshold, then it makes sense not to favor more transparency as this may enable firms to collude more easily. This result is in stark contrast to the outcome in case of inelastic demand derived by Schultz (2005) who finds that a fully transparent market always benefits customers as the stability of collusive agreements is reduced. Therefore, from a practical point of view, the aim of competition authorities in many jurisdictions to improve customers' access to price information (see Section 1) does not necessarily have the desired collusion-deterring effect.

Note, however, that competition authorities may not be in full control of transparency. Nevertheless, one may make use of the above results in a situation where the authority is only able to affect transparency at the margin. For example, if the degree of transparency is already to the right of the bottom of the U, then a small increase in transparency may in fact be better for customers than a small decrease.

In this context, we point out that increasing the level of transparency may give rise to a trade-off for customers, who favor lower prices. However, marginal control on the competition authority's side may be sufficient to achieve a better market outcome for customers if this leads to a breakdown of collusive practices. Note first that in a competitive environment, customers always prefer an increased level of transparency over a more opaque market as competitive prices are lower. As a result, whenever a competition authority (marginally) increases market transparency in order to destabilize collusion, this is unambiguously good news for customers as competitive prices go down at the same time. On the other hand, if a (marginal) decrease of market transparency is necessary to destabilize collusion (in particular when firms are rather differentiated), this comes along with higher competitive prices for customers. However, as collusive prices do not depend on the level of price transparency and equal the ones in a completely opaque market, competitive prices are always below collusive prices. This means that customers strictly prefer collusion deterrence at the cost of higher competitive prices. These effects are less of an issue if firms are very differentiated: in this case, firms' competitive prices are almost equal to their monopoly prices—independent of the level of market transparency.

4. Conclusion

Competition authorities often tend to favor the idea of well informed customers. This article addresses the question whether increased price transparency on the customer side stabilizes collusion when horizontally differentiated firms face an elastic demand. It is shown that the answer depends on the degree of differentiation: for low levels of differentiation, there is an ambiguous effect and collusion is most stable neither under non-transparency nor under full transparency. However, different from competition authorities' understanding but in line with empirical and experimental evidence (see Section 1), for higher levels of differentiation, full transparency implies the highest degree of collusive stability. This result reverses the finding of Schultz (2005) that full transparency is always optimal when customers' demand is inelastic. The present article therefore highlights an important aspect which has not been considered so far, namely that attention should be paid to demand characteristics when thinking about the ideal degree of customer-side transparency. As a matter of fact, with elastic demand and heterogeneous local demand, the competition effect which is the only effect present in models with inelastic demand may be outweighed by the elasticity effect.

Putting the above results in a broader context, we point out that competition authorities need to take into account multiple important market features. Given the results mentioned in Section 1, the type of decision variable or parameter affected by a change in market transparency on the customer side appears to be crucial (search costs, product differentiation, price). With respect to price transparency, demand characteristics seem to play an important role (elastic vs. inelastic demand). At the same time, it is important to assess the degree of differentiation in the market. Moreover, the level of transparency in the market is also an important aspect as further increasing transparency may actually facilitate collusion.

Appendix A

A.1. Derivation of profits

In this part, we first analyze competitive and collusive prices and profits. The collusive price is then used to derive the deviating price and the resulting profit.

A.1.1. Competitive profits

Consider the case where the indifferent customer $\tilde{x}^N$ is located in between the two firms, i.e., $0 \leqslant \tilde{x}^N \leqslant 1$. Then, demand at firm 1 in the competitive case is given by

$$Q_1^N = \alpha \int_0^{\frac{1}{2}-\frac{p_1^N - p_2^N}{2\tau}} (1 - \tau x - p_1^N) dx + (1-\alpha) \int_0^{\frac{1}{2}} (1 - \tau x - p_1^N) dx. \quad (4)$$

As mentioned before, we will focus on a symmetric competitive equilibrium. In this case, the indifferent uninformed customer is located halfway between the two firms in equilibrium.

Firm 1's profits are given by $\pi_1^N = p_1^N Q_1^N$. Proceeding in the standard way to derive the optimal symmetric equilibrium prices and dropping subscripts, we get

$$p^N = \frac{2\alpha - \alpha\tau + 4\tau - \sqrt{A}}{4\alpha}$$

where $A := 4\alpha^2 - 4\alpha^2\tau + \alpha^2\tau^2 - 4\alpha\tau^2 + 16\tau^2 > 0\ \forall\alpha \in (0,1], \tau \in [\underline{\tau}, \bar{\tau}]$.[17]

As both firms charge the same equilibrium price, the indifferent customer will be located at $\tilde{x}^N = 1/2$. Moreover, the demand of a customer located at x amounts to

$$q^N(x) = \frac{2\alpha + \alpha\tau(1-4x) - 4\tau + \sqrt{A}}{4\alpha}.$$

Clearly, as this expression is decreasing in x, the most critical case is the one where $x = \tilde{x}^N$. If the market is to be covered, even the indifferent customer must have an incentive to demand a non-negative quantity of the product, i.e., $q^N(\tilde{x}^N) \geqslant 0 \iff \tau \leqslant 4/3$ must hold which is satisfied due to Assumption 1.

The resulting profit for each firm then equals

$$\pi^N = \frac{(2\alpha - \alpha\tau + 4\tau - \sqrt{A})(2\alpha - 4\tau + \sqrt{A})}{32\alpha^2}.$$

Note that Assumption 1 (lower bound) indeed ensures that a firm is not better off when catering to the uninformed customers only. To see this, denote by π_i^a firm i's profit for this case. Then, the maximization problem yields the following price:

$$\max_{p_i^a} \pi_i^a = p_i^a(1-\alpha)\int_0^{\frac{1}{2}}(1 - \tau x - p_i^a)dx \iff p^a = \frac{1}{2} - \frac{\tau}{8}.$$

The associated profit is given by

$$\pi^a = \frac{(1-\alpha)(4-\tau)^2}{128}.$$

Comparing the profits in both cases reveals that $\pi^N \lesseqgtr \pi^a \Leftrightarrow \tau \lesseqgtr \underline{\tau}$. Hence, Assumption 1 ensures that it is never optimal to target the uninformed customers exclusively.

A.1.2. Collusive profits

In the case of tacit collusion, firms coordinate their price-setting decision and share the market equally, i.e., $\tilde{x}^C = 1/2$. This leads to a total demand per colluding firm of

$$Q_i^C = \int_0^{\frac{1}{2}}(1 - \tau x - p_i^C)dx.$$

The optimal collusive price[18] is set at

$$p^C = \frac{1}{2} - \frac{\tau}{8}.$$

The demand of a customer located at x then equals

$$q^C(x) = \frac{1}{2} + \frac{\tau}{8} - \tau x. \tag{5}$$

Again, the most critical case is the one where $x = \tilde{x}^C$ to check whether the market is covered. Similar to the argument before, we find that $q^C(\tilde{x}^C) \geqslant 0$ as long as $\tau \leqslant 4/3$.

The associated profit for each firm is then given by

$$\pi^C = \frac{(4-\tau)^2}{128}.$$

Given this collusive profit, it is now possible to derive the deviating profit.

A.1.3. One-period deviation profits

Under the assumption that the other firm sticks to the collusive price and $0 \leqslant \tilde{x}^D \leqslant 1$, the optimal deviating price is given by

$$p^D = \frac{40\alpha - 18\alpha\tau + 32\tau - \sqrt{B}}{72\alpha}$$

where $B := 592\alpha^2 - 648\alpha^2\tau + 189\alpha^2\tau^2 + 256\alpha\tau - 576\alpha\tau^2 + 1024\tau^2 > 0\ \forall\alpha \in (0,1], \tau \in [\underline{\tau}, \bar{\tau}]$.[19]

As both firms charge different prices in this situation, the indifferent customer is no longer located at the center of the unit line. More precisely, assuming without loss of generality that firm 1 deviates from the collusive agreement, the indifferent customer can be found at

$$\tilde{x}^D = \frac{-4\alpha + 81\alpha\tau - 32\tau + \sqrt{B}}{144\alpha\tau}.$$

Clearly, a deviating firm cannot capture a market share that is greater than 1 which means that the above expression is valid as long as $\tilde{x}^D \leqslant 1$. Solving this inequality for τ gives $4(\sqrt{121\alpha^2 + 128\alpha} - 4\alpha)/(128 + 105\alpha) =: \tilde{\tau}$ where $\underline{\tau} \leqslant \tilde{\tau}$. For any $\tau \in [\underline{\tau}, \tilde{\tau}]$, the relevant deviating price can be found by assuming $p_2 = p^C$ and solving $\tilde{x}^D = 1$ for p_1. Hence, the deviating price is given by

$$p^D = \begin{cases} \frac{1}{2} - \frac{9\tau}{8} & \text{if } \tau \leqslant \tilde{\tau} \\ \frac{40\alpha - 18\alpha\tau + 32\tau - \sqrt{B}}{72\alpha} & \text{else.} \end{cases}$$

Furthermore, the demand of a customer who is located at x and who buys from the deviating firm (here firm 1) amounts to

$$q^D(x) = \begin{cases} \frac{1}{2} + \frac{9\tau}{8} - \tau x & \text{if } \tau \leqslant \tilde{\tau} \\ \frac{32\alpha + 18\alpha\tau(1-4x) - 32\tau + \sqrt{B}}{72\alpha} & \text{else} \end{cases}$$

which is positive given Assumption 1.

The deviating profit[20] thus amounts to

$$\pi^D = \begin{cases} \frac{1+\alpha}{8} - \frac{(1+3\alpha)\tau}{16} - \frac{(63+27\alpha)\tau^2}{128} \\ (-40\,\alpha + 18\,\alpha\tau - 32\,\tau - \sqrt{B}) \\ \times \frac{-208\alpha^2 + 72\alpha^2\tau^2 + 27\alpha^2\tau^2 - 1024\alpha\tau + 512\tau^2 - \sqrt{B}(20\alpha - 9\alpha\tau + 16\tau)}{497664\alpha^2\tau}. \end{cases}$$

$$(-40\alpha + 18\alpha\tau - 32\tau - \sqrt{B}) \times \frac{-208\alpha^2 + 72\alpha^2\tau^2 + 27\alpha^2\tau^2 - 1024\alpha\tau + 512\tau^2 - \sqrt{B}(20\alpha - 9\alpha\tau + 16\tau)}{497664\alpha^2\tau}$$

[17] Note that $\partial p/\partial\alpha < 0$ and that—applying de l'Hôpital's rule—for $\alpha \to 0$, $p = 1/2 - \tau/8$ which is equal to the collusive price p^C (see below).

[18] We focus on full collusion here where firms set the maximum collusive price. Any lower collusive price would also be sustainable for any discount factor above the critical one. As Chang (1991) points out, firms may adjust their collusive prices downwards in order to ensure that condition (3) is (just) met even if the discount factor is below the critical one. We do not further analyze this case as results should be qualitatively the same.

[19] Note that $\partial p^D/\partial\alpha < 0$ and that $p^D = p^C$ as $\alpha \to 0$.

[20] Note that as $\alpha \to 0$, it holds that $\pi^N = \pi^C = \pi^D$.

A.2. Limit cases

In this section, we have a closer look at the extreme cases, i.e., at those situations where firms are either hardly or very differentiated and where the market is either completely opaque or fully transparent. We then use these findings to prove the two propositions from the main text.

We can state the following result concerning the impact of differentiation on the stability of collusion:

Lemma 1. *If the market is completely opaque (i.e., $\alpha \to 0$), a change in the degree of differentiation has no impact on the stability of collusion. If the market is fully transparent (i.e., $\alpha = 1$), an increase in differentiation has an ambiguous effect: it first destabilizes collusion, then stabilizes it before collusion is destabilized again.*

Proof. The first part of the proof follows simply from considering the derivative $\partial\bar{\delta}(\tau,0)/\partial\tau$. As far as $\partial\bar{\delta}(\tau,1)/\partial\tau$ is concerned, setting the derivative equal to 0 and solving for τ gives two solutions which we denote by $\tau' \approx 0.15237$ and $\tau'' \approx 0.62060$. As $\partial\bar{\delta}(\tau,1)/\partial\tau = 1/2$ at $\tau = \underline{\tau}$, it must be true that, starting from $\tau = \underline{\tau}$, an increase in τ first leads to an increase in $\bar{\delta}(\tau,1)$ before it decreases and then increases again. Summing up, if $\alpha \to 0$, it holds that $\partial\bar{\delta}(\tau,0)/\partial\tau = 0\ \forall\tau \in [\underline{\tau},\bar{\tau}]$. If $\alpha = 1$, then there exist a τ' and a τ'' such that $\partial\bar{\delta}(\tau,1)/\partial\tau > 0\ \forall\tau \in [\underline{\tau},\tau') \cup (\tau'',\bar{\tau}]$ and $\partial\bar{\delta}(\tau,1)/\partial\tau < 0\ \forall\tau \in (\tau',\tau'')$. □

Concerning the impact of the degree of transparency, we can state the following result:

Lemma 2. *If the degree of differentiation is low, then there exists a threshold of the transparency parameter such that an increase in transparency leads to more (less) collusive stability below (above) this threshold. If firms are very differentiated, an increase in transparency always stabilizes collusion.*

Proof. Let $\tau = \underline{\tau}$ and consider $\partial\bar{\delta}(\underline{\tau},\alpha)/\partial\alpha = 0$. Solving this equality for α gives a unique solution in the relevant parameter space which is denoted by α' and which is approximately equal to 0.05730. As $\partial\bar{\delta}(\underline{\tau},\alpha)/\partial\alpha = 0.0625$ at $\alpha = 1$, it must be true that starting from $\alpha \to 0$, an increase in α first leads to a decrease in $\bar{\delta}(\underline{\tau},\alpha)$ before it increases. Next consider the case where $\tau = \bar{\tau}$: in this case, setting $\partial\bar{\delta}(\bar{\tau},\alpha)/\partial\alpha = 0$ does not give a solution in the relevant parameter space. Moreover, we find that $\bar{\delta}(\underline{\tau},0) = 1/2$. As we know from Lemma 1 that $\partial\bar{\delta}(\tau,0)/\partial\tau = 0$, it must hold that $\bar{\delta}(\bar{\tau},0) = \bar{\delta}(\underline{\tau},0) = 1/2$. As we have $\bar{\delta}(\bar{\tau},1) = 49/101$, we can conclude that $\bar{\delta}(\bar{\tau},\alpha)$ decreases in α. Summing up, if $\tau = \underline{\tau}$, then there exists an α' such that $\partial\bar{\delta}(\underline{\tau},\alpha)/\partial\alpha < 0\ \forall\alpha \in (0,\alpha')$ and $\partial\bar{\delta}(\underline{\tau},\alpha)/\partial\alpha > 0\ \forall\alpha \in (\alpha',1]$. If $\tau = \bar{\tau}$, then $\partial\bar{\delta}(\bar{\tau},\alpha)/\partial\alpha < 0\ \forall\alpha \in (0,1]$. □

A.3. Proof of Proposition 1

Proof. We start by solving $\partial\bar{\delta}(\tau,\alpha)/\partial\alpha = 0$ for α which gives $\alpha(\tau)''$ as the unique solution in the relevant parameter space, i.e., $\alpha(\tau)'' \in (0,1]$. Note that $\partial\alpha(\tau)''/\partial\tau > 0$. From Lemma 2 we know that $\alpha(\underline{\tau})'' = \alpha' \approx 0.05730$. Moreover, solving $\alpha(\tau)'' = 1$ for τ gives $\hat{\tau}$ as a solution which is approximately equal to 0.52543. The observation that $\partial\bar{\delta}(\tau,\alpha)/\partial\alpha > 0$ at $\alpha = 1$ if $\tau < \hat{\tau}$ and $\partial\bar{\delta}(\tau,\alpha)/\partial\alpha < 0$ at $\alpha = 1$ if $\tau > \hat{\tau}$ completes the proof. Note that if $\tau > \hat{\tau}$, then $\bar{\delta}(\tau,\alpha)$ attains a minimum with respect to α at $\alpha = 1$. Summing up, there exist a $\hat{\tau}$ and an $\alpha(\tau)''$ with $\alpha(\tau)'' \in (0,1]$ such that $\partial\bar{\delta}(\tau,\alpha)/\partial\alpha < 0\ \forall\alpha \in (0,\alpha(\tau)'')$ and $\partial\bar{\delta}(\tau,\alpha)/\partial\alpha > 0\ \forall\alpha \in (\alpha(\tau)'',1]$ if $\tau \leqslant \hat{\tau}$. If $\tau > \hat{\tau}$, then $\partial\bar{\delta}(\tau,\alpha)/\partial\alpha < 0\ \forall\alpha \in (0,1]$. □

A.4. Proof of Proposition 2

Proof. In light of the result from Proposition 1, it is sufficient to compare both $\bar{\delta}(\tau,0)$ and $\bar{\delta}(\tau,1)$ in order to analyze whether full transparency is optimal. Clearly, as follows from Proposition 1, full transparency cannot be optimal whenever $\tau > \hat{\tau}$. From the proof of Lemma 1 we know that $\bar{\delta}(\tau,0) = 1/2\ \forall\tau \in [\underline{\tau},\bar{\tau}]$. Then, setting $\bar{\delta}(\tau,1) = 1/2$ and solving for τ gives a unique solution in the relevant parameter space which we denote by τ_r and which approximately equals 0.31319. Making use of the result in Lemma 1 that $\partial\bar{\delta}(\tau,1)/\partial\tau < 0$ for $\tau < \tilde{\tau}$ (where $\tilde{\tau} > \hat{\tau}$), we can conclude that $\bar{\delta}(\tau,1) \geqslant 1/2$ holds if $\tau \leqslant \tau_r$. Hence, a competition authority favors full transparency only if $\tau \leqslant \tau_r < \hat{\tau}$. □

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References

Abreu, D., 1986. Extremal equilibria of oligopolistic supergames. Journal of Economic Theory 39, 191–225.

Abreu, D., 1988. On the theory of infinitely repeated games with discounting. Econometrica 56, 383–396.

Abreu, D., Pearce, D.G., Stacchetti, E., 1986. Optimal cartel equilibria with imperfect monitoring. Journal of Economic Theory 39, 251–269.

Albæk, S., Møllgaard, P., Overgaard, P.B., 1997. Government-assisted oligopoly coordination? A concrete case. Journal of Industrial Economics 45, 429–443.

Azzam, A.M., 2003. Market transparency and market structure: the Livestock Mandatory Reporting Act of 1999. American Journal of Agricultural Economics 85, 387–395.

Azzam, A.M., Salvador, S., 2004. Information pooling and collusion: an empirical analysis. Information Economics and Policy 16, 275–286.

Capobianco, A., Fratta, S., 2005. Information exchanges between competitors: the Italian Competition Authority's recent practice. Competition Law Insight 4, 3–6.

Chang, M.-H., 1991. The effects of product differentiation on collusive pricing. International Journal of Industrial Organization 9, 453–469.

Friedman, J., 1971. A non-cooperative equilibrium for supergames. Review of Economic Studies 38, 1–12.

Gu, Y., Wenzel, T., 2009. A note on the excess entry theorem in spatial models with elastic demand. International Journal of Industrial Organization 27, 567–571.

Gu, Y., Wenzel, T., 2012. Transparency, entry, and productivity. Economics Letters 115, 7–10.

Gupta, B., Venkatu, G., 2002. Tacit collusion in a spatial model with delivered pricing. Journal of Economics 76, 49–64.

Häckner, J., 1996. Optimal symmetric punishments in a Bertrand differentiated products duopoly. International Journal of Industrial Organization 14, 611–630.

Hong, J.T., Plott, C.R., 1982. Rate filing policies for inland water transportation: an experimental approach. Bell Journal of Economics 13, 1–19.

Hotelling, H., 1929. Stability in competition. Economic Journal 39, 41–57.

Kühn, K.-U., 2001. Fighting collusion by regulating communication between firms. Economic Policy 16, 169–204.

Kühn, K.-U., Vives, X., 1995. Information Exchanges among Firms and Their Impact on Competition. Office for Official Publications of the European Community, Luxemburg.
Mérel, P.R., Sexton, R.J., 2010. Kinked-demand equilibria and weak duopoly in the Hotelling model of horizontal differentiation. B.E. Journal of Theoretical Economics (Contributions) 10 (Article 12).
Møllgaard, H.P., Overgaard, P.B., 2001. Market transparency and competition policy. Rivista di Politica Economica 91, 11–64.
Møllgaard, H.P., Overgaard, P.B., 2002. Market transparency: a mixed blessing? Mimeo.
Møllgaard, H.P., Overgaard, P.B., 2006. Transparency and competition policy. In: Bergman, M. (Ed.), The Pros and Cons of Information Sharing. Swedish Competition Authority, Stockholm, pp. 101–129.
Nilsson, A., 1999. Transparency and Competition. SSE/EFI Working Paper Series in Economics and Finance No. 298.
Njoroge, K., 2003. Information pooling and collusion: implications for the Livestock Mandatory Reporting Act. Journal of Agricultural and Food Industrial Organization 1 (Article 14).
Overgaard, P.B., Møllgaard, H.P., 2008. Information exchange, market transparency, and dynamic oligopoly. In: Wayne Dale Collins (Ed.), Issues in Competition Law and Policy, vol. 2. American Bar Association Section of Antitrust Law, Chicago, pp. 1241–1268.
Puu, T., 2002. Hotelling's 'ice cream dealers' with elastic demand. Annals of Regional Science 36, 1–17.
Rothschild, R., 1997. Product differentiation and cartel stability: Chamberlin versus Hotelling. Annals of Regional Science 31, 259–271.
Schultz, C., 2004. Market transparency and product differentiation. Economics Letters 83, 173–178.
Schultz, C., 2005. Transparency on the consumer side and tacit collusion. European Economic Review 49, 279–297.
Schultz, C., 2009a. Transparency and product variety. Economics Letters 102, 165–168.
Schultz, C., 2009b. Collusion in Markets with Imperfect Price Information on Both Sides. CIE Discussion Papers No. 2009-01, University of Copenhagen.
Varian, H., 1980. A model of sales. American Economic Review 70, 651–659.
Wachenheim, C.J., DeVuyst, E.A., 2001. Strategic response to mandatory reporting legislation in the U.S. livestock and meat industries: are collusive opportunities enhanced? Agribusiness 17, 177–195.