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

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Abstract

We analyze the effect of market transparency on the customer side on the possibility to sustain maximum collusive profits for horizontally differentiated firms that face an elastic demand. It is shown that there is a non-monotone relationship for low levels of differentiation. If, however, the degree of differentiation is high, a more transparent market makes full collusion easier to sustain. This is due to the fact that with elastic demand, the firms’ pricing decisions not only affects the indifferent customer’s type but also impacts on the inframarginal customers’ behavior.

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Keywords: critical discount factor, elastic demand, horizontal product differentiation, market transparency, tacit collusion.

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1 Introduction

The question of whether better informed customers are good for competition is of great importance both for competition authorities as well as for consumer protection agencies. Practitioners seem to consider an increased market transparency on the customer side as an appropriate means to promote competition. E.g., in Germany 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 with respect to 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 paper, we use a specification à la Hotelling (1929) where the two firms in the market face an elastic demand. We study the effects of a higher degree of price transparency among customers on collusive stability. Generally speaking, there are two opposing effects due to an increased transparency: On the one hand, undercutting the other firm’s price increases the profit of the deviating firm as more customers will actually take notice of the price cut. On the other hand, this increased price awareness leads to a tougher

price competition, i.e. the punishment is harder. Applying the concept of trigger strategies, we show that for a relatively low degree of differentiation, the implications of an increase in market transparency are ambiguous and full transparency may be desirable in order to destabilize collusion. If, however, the degree of differentiation is sufficiently high, a greater market transparency stabilizes collusion. These results can be explained by pointing out that with elastic demand, a change in prices by one firm not only affects the location of the marginal customer but has implications for the inframarginal customers’ purchasing decision at the same time. More precisely, the elasticity of demand softens the effect of a price cut as it increases the demand among the inframarginal customers. On the other hand, a (unilateral) price increase reduces both the market share and the inframarginal customers’ demand. Hence, as competitive and deviating prices must be lowered for high transportation costs under elastic demand, collusion can be sustained for a greater range of discount factors in such a situation. Now, if market transparency is increased, prices must decrease both in the competitive and the deviating case. The effect of this price cut, however, is not as strong as under inelastic demand as local demand is higher. As a consequence, profits are relatively higher which compensates for the destabilizing effect of high transportation costs.

Unlike the literature dealing with the effects of information exchange between firms on the likelihood of collusion, there are only a few papers that look at the implications of different levels of market transparency on the customer side.² Our paper is closely related to the contribution by Schultz (2005). He sets up a Hotelling (1929) model with inelastic demand to analyze the

²For an overview of the implications of information exchange for coordinated behavior, see, e.g., Kühn and Vives (1995) as well as Kühn (2001). Concerning the issue of market transparency on the customer side, see Møllgaard and Overgaard (2006) for an overview.
implications of customer-side price transparency for the stability of tacit collusion. The author shows that—contrary to what we find—a higher degree of transparency unambiguously destabilizes collusion.

Nilsson (1999) develops a model with unit demand and homogeneous products. He associates a higher degree of transparency with lower search costs. There are two groups of customers that actually search: Those who enjoy shopping and searching just for the sake of it, i.e. independent of its effectiveness, and those who derive a positive net benefit from searching. The model suggests an ambiguous relationship between transparency and collusive stability. The exact outcome depends on the relative strength of the increase in both groups in the wake of a drop in search costs.

Møllgaard and Overgaard (2001) define market transparency as customers’ ability to compare the products’ characteristics or quality. 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 which contrasts our results. Moreover, they find that full transparency is unambiguously optimal with two firms when applying optimal symmetric penal codes following Abreu (1986, 1988).

From an empirical point of view, Albæk, Møllgaard, and Overgaard (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. However, the argument often put forward to explain this result is that by giving customers more information firms learn about competitors’ prices at the same time. This, however, makes punishment easier and therefore facilitates collusion. Our analysis suggests a different—or complementary—explanation for the observation of increased prices: A

\[ \text{3Full transparency is shown to be optimal for five or more firms.} \]
higher degree of transparency on the customer side may have a stabilizing
effect for collusion as well—just like a better access to information about
competitors’ behavior.

In their experimental study, Hong and Plott (1982) analyzed the possible
consequences of a proposed rate publication policy for the domestic barge
industry on inland waterways in the United States. Back then, 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 Inter-
state Commerce Commission (ICC) at least fifteen days before the new rate was to become effective. The authors find that a publication policy
resulted in higher prices, lower volume, and reduced efficiency in the labora-
tory. Moreover, the introduction of such a policy hurt the small participants.\(^4\)

In the next section, the model along with the main result is presented. The
last section concludes.

### 2 The model

There are two firms which are located at the two extremes of the Hotelling
(1929) line of unit length. Customers of mass 1 are uniformly distributed
along the line. To include different transparency levels, only a share \(\alpha\) of the
customers are assumed to be informed about the prices charged by the firms.

As we are interested in the implications of a change in price transparency
under elastic demand, let \(q\) denote the quantity a customer demands at a
given price and location. Then, a customer located at \(x\) derives the following

\(^4\)Note that it is true that conversations on price collusion were strictly forbidden but
clearly, there was room for tacit collusion.
utility

\[ u = \begin{cases} 
q - \frac{q^2}{2} - q \left( \tau x + p_1 \right) & \text{when buying from firm 1} \\
q - \frac{q^2}{2} - q \left( \tau (1 - x) + p_2 \right) & \text{when buying from firm 2}, 
\end{cases} \tag{1} \]

where \( \tau \) measures the degree of differentiation between the two firms (transportation costs) and where \( p_i \) 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. This utility specification is equivalent to a local demand function of

\[ q_i(p_i, x) = 1 - \tau x - p_i. \tag{2} \]

As a consequence, the indifferent (informed) customer located at \( \tilde{x} \) is given by

\[ 1 - \tau \tilde{x} - p_i = 1 - \tau (1 - \tilde{x}) - p_j \iff \tilde{x} = \frac{1}{2} - \frac{p_i - p_j}{2\tau}, \tag{3} \]

where \( i \neq j \). On the other hand, those customers belonging to the share \( 1 - \alpha \) of the population that are uninformed always buy from the closest firm. Thus, the indifferent uninformed customer is given by \( \tilde{x} = \frac{1}{2} \). Note that the uninformed customers have the same elastic demand.

Before continuing with the analysis, the following assumption is made:

**Assumption** \( \tau \equiv \frac{4(\sqrt{121\alpha^2+128\alpha^2}-4\alpha)}{128+165\alpha} \leq \tau \leq \frac{1}{3} \equiv \bar{\tau}. \)

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5Rothschild (1997) has a comparable specification. His results the same like ours for the limit case with informed customers only (\( \alpha = 1 \)). 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.
This assumption ensures that the deviating firm’s market share is always less or equal to 1 and that each firm will target both groups of customers (lower bound). At the same time, applying an upper bound on this parameter ensures that the market is covered and that a customer’s utility is non-negative, i.e. every customer will go to either of the two firms even if firms charge the monopoly price. Moreover, the upper bound also means that firms can secure non-negative profits in any circumstance.\footnote{Note that only the lower bound depends on the market transparency parameter. This is due to the fact that the deviating price is a function of $\alpha$ whereas the monopoly price is not (see below).}

To analyze the effects of transparency on the sustainability of collusion, we focus on the standard trigger strategies defined by Friedman (1971). Thus, collusion is stable as long as the discount factor is higher than the critical one defined by the profits in the competitive, collusive, and deviating cases (superscripts $N$, $C$, and $D$, respectively):\footnote{The critical discount factor is due to the requirement that profits from collusion must be higher than those from deviation and the ensuing punishment phase, i.e. $\frac{\bar{\delta}^C}{1-\bar{\delta}} \geq \frac{\pi^D - \pi^C}{\pi^D - \pi^N}$.}

\[
\delta \geq \bar{\delta} \equiv \frac{\pi^D - \pi^C}{\pi^D - \pi^N}. \tag{4}
\]

Next, we derive the profits in the three scenarios.

**Punishment: competition in prices**

In the competitive case, demand at firm $i$ is given by

\[
Q_i^N = \alpha \int_0^\frac{1}{2} \frac{p_i^N - p_j^N}{2\tau} \left(1 - \tau x - p_i^N\right) dx + (1 - \alpha) \int_0^\frac{1}{2} \left(1 - \tau x - p_i^N\right) dx. \tag{5}
\]
Firms’ profits are thus \( \pi^N_i = p^N_i Q^N_i \). Proceeding in the standard way to derive the optimal price, we get

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

where \( A \equiv 16\tau^2 - 4\alpha \tau^2 + \alpha^2 \tau^2 - 4\alpha^2 \tau + 4\alpha^2 > 0 \) \( \forall \alpha \in [0; 1], \tau \in [\tau; \bar{\tau}] \). The resulting profit for each firm then equals

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

Collusive profits

In the case of tacit collusion, firms coordinate their price-setting decision and share the market equally. This leads to an individual total demand of

\[
Q^C_i = \int_0^{1/2} (1 - \tau x - p^C_i) \, dx.
\]

The optimal collusive price is set at

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

The associated profit for each firm is then given by

Note that \( \frac{\partial p}{\partial \alpha} < 0 \) and that—applying de l’Hôpital’s rule—\( \lim_{\alpha \to 0} p = \frac{1}{2} - \frac{\tau}{8} \) which is equal to the collusive price \( p^C \) (see below).
\[ \pi^C = \frac{(4 - \tau)^2}{128}. \]  \hfill (10)

**One-period deviation profits**

Given that the other firm sticks to the collusive price, the optimal deviating price is given by

\[ p^D = \frac{32\tau - 18\alpha\tau + 40\alpha - \sqrt{B}}{72\alpha} \]  \hfill (11)

where \( B \equiv 1024\tau^2 + 189\alpha^2\tau^2 - 576\alpha\tau^2 + 256\alpha\tau - 648\alpha^2\tau + 592\alpha^2 > 0 \forall \alpha \in [0; 1], \tau \in [\tau_\ast; \bar{\tau}] \).\(^9\) The deviating profit thus amounts to

\[ \pi^D = \frac{\left(-32\tau - 40\alpha + 18\alpha\tau + \sqrt{B}\right) \cdot (512\tau^2 + 27\alpha^2\tau^2 - 1024\alpha\tau + 72\alpha^2\tau - 208\alpha^2 - \sqrt{B}(16\tau + 20\alpha - 9\alpha\tau))}{497664\alpha^2\tau}. \]  \hfill (12)

**Critical discount factor**

Making use of the results from the three different cases, we can calculate the critical discount factor. We find the following relationship:

**Proposition** There exist an \( \tilde{\alpha} \) and a \( \tilde{\tau} \) such that

\[ \frac{\partial \delta}{\partial \alpha} \begin{cases} 
\leq 0 & \text{if } \tau \leq \tilde{\tau} \text{ and } \alpha \leq \tilde{\alpha}, \\
> 0 & \text{otherwise.} 
\end{cases} \]  \hfill (13)

\(^9\)Again, note that \( \frac{\partial p^D}{\partial \alpha} < 0 \) and that \( \lim_{\alpha \to 0} p^D = p^C \).
Proof See the appendix.

As the proposition suggests, the relationship between collusive stability and market transparency is non-monotonous for the case of low transportation costs.

Figure 1: \( \arg\min_{\alpha} \delta(\alpha, \tau) \) and \( \arg\min_{\tau} \delta(\alpha, \tau) \)

Figure 1 depicts the degree of market transparency which yields the lowest discount factor for a given differentiation parameter. For low values of \( \alpha \), it also shows the degree of differentiation resulting in the lowest discount factor.

Interestingly, an increase in market transparency always leads to a lower critical discount factor if the degree of differentiation is relatively high. This result is in stark contrast to the findings in Schultz (2005) with inelastic demand. In order to understand the reason for this difference, consider first the impact of a change in transportation costs for the case of full market transparency. If transportation costs are rather low, then—and in line with the
situation where customers have inelastic demand—an increase in these costs leads to a stabilization of the collusive agreement, i.e. deviation is (relatively) less attractive. On the other hand, if transportation costs are high, the outcome is reversed. Note that with elastic demand, we have $\frac{\partial p^N}{\partial \tau} < 0$ as well as $\frac{\partial p^D}{\partial \tau} < 0$ for large values of $\tau$.\(^\text{10}\) Different from what is true in the case with inelastic demand, deviation becomes more attractive. This can be explained as follows: A deviating firm must capture more than half of the market. This means that the marginal customer is located more closely toward the other firm. Therefore, the deviating firm has to lower its price if transportation costs go up—even more so, if transportation costs are high. If customers have an inelastic demand, this price cut fully impacts on profits. In the case of elastic demand considered here, such a price reduction increases the local demand by the inframarginal customers which means that the resulting negative implications for the deviating firm’s profits are reduced. Ultimately, deviation becomes relatively more attractive. The same argument can be put forward for the competitive case when transportation costs are high, i.e. punishment is not as severe. Put together, it holds that although prices decrease with an increase in transportation costs thus stabilizing collusion, the resulting decrease in profits is more moderate as local demand is higher. The latter effect leads to a destabilization of the collusive agreement and dominates the former. For low transportation costs, competitive and deviating prices increase when transportation costs rise and the two effects just described are reversed ultimately leading to a higher sustainability of collusion. For an illustration, see Figure 2.\(^\text{11}\)

\(^\text{10}\)More precisely, this is indeed the case whenever $\tau > \frac{2(1+3\sqrt{3})}{13} \approx 0.95325$ and $\tau > \frac{1}{13} + \frac{32\sqrt{3}}{91} \approx 0.91677$, respectively.
When it comes to the impact of the degree of market transparency, there is a similar relationship: A higher market transparency leads to a lower price both in the competitive and the deviating case. This price reduction has a weaker effect—compared to the case of inelastic demand—on both profits as it increases local demand. As a result, deviating becomes more profitable whereas the competitive profit is lowered to a lesser extent thus reducing (strengthening) the (de)stabilizing effect of low (high) transportation costs. Figure 3 illustrates.
Given the examples in the introduction, it seems interesting to also consider the role of a competition authority. Obviously, a competition authority is interested in a discount factor as high as possible. Let $\tilde{\tau}_R \equiv \arg_{\tau}(\bar{\delta}(\alpha = 0) = \delta(\alpha = 1))$. Then, making use of the result from the proposition, we can derive the following result:

**Corollary** From the perspective of the competition authority, full transparency is optimal only if $\tau \leq \tilde{\tau}_R < \tilde{\tau}$.

Hence, a competition authority would want a fully transparent market only if the degree of differentiation is sufficiently low.\(^{11}\) This case is represented by the area to the left of the vertical line in the figure. Note, however, that due to the ambiguous impact of $\alpha$ on the critical discount factor for low levels of differentiation, increasing transparency only a little bit may actually be

\(^{11}\)More precisely, $\tilde{\tau}_R \approx 0.31319$. 

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detrimental. If the degree of differentiation is above this threshold, then it may make sense not to favor more transparency on the customer side as this may enable firms to collude. Nevertheless, rendering the market completely intransparent is not an option as this would imply monopoly prices for customers as well.

3 Conclusions

This paper addresses the question whether increased market 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 with the lowest critical discount factor being no corner solution. If, on the other side, firms are very differentiated, full transparency implies the highest degree of collusive stability.

Competition authorities therefore have to take into account several important market features. Given the results mentioned in the introduction, the type of decision variable or parameter affected by a change in market transparency on the customer side seems to be crucial. With respect to price transparency, demand characteristics seem to play an important role. At the same time, it is important to assess the degree of differentiation in the market. More generally, the level of transparency that has already been achieved is important as well since an increase may be good or bad news for the stability of the collusive agreement.
Appendix

Proof of the proposition

Proof An obvious approach to investigating the impact of $\alpha$ on $\bar{\delta}$ would be to consider $\frac{\partial \bar{\delta}}{\partial \alpha}$. However, as it turns out, this expression is not tractable which is why we follow a different direction: We first set $\frac{\partial \bar{\delta}}{\partial \tau} = 0$ and solve for $\alpha$ in order to get the extremal values of the critical discount factor for any combination of $\alpha$ and $\tau$ denoted by $\hat{\alpha}$. Note that $\hat{\alpha}$ is a function of $\tau$. As $0 \leq \hat{\alpha} \leq 1$ must hold, we need to check whether this condition is satisfied.

It holds that $\hat{\alpha} > 0 \forall \tau \in [\tau_{\bar{\delta}}; \bar{\tau}]$. Solving $\hat{\alpha} = 1$ for $\tau$ gives $\bar{\tau} \approx 0.62060$ as a solution. As $\bar{\delta}$ reaches an extremum for $\alpha = 1$ and $\tau = \bar{\tau}$, it follows that for any $\alpha < 1$ and $\tau > \bar{\tau}$, the sign of $\frac{\partial \bar{\delta}}{\partial \alpha}$ does not change. Since we have $\bar{\delta}(\alpha = \frac{1}{2}, \tau = 1) \approx 0.48845 > 0.47728 \approx \bar{\delta}(\alpha = 1, \tau = 1)$, $\hat{\alpha}$ gives the minimum values for the discount factor and $\tau \geq \bar{\tau} \Rightarrow \frac{\partial \bar{\delta}}{\partial \alpha} < 0$. ■

References


