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Let's Lock Them in: Collusion under Consumer Switching Costs *

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Abstract

Consumer switching costs cause the market demand of consumers who already bought a supplier's product to be less elastic while they simultaneously increase competition for new consumers. I study the effect of this twofold pricing incentive on firms' price setting behavior in a 2x2 factorial design experiment with and without communication and under present and absent switching costs. For Bertrand duopolies consumer switching costs reduce the price level vis-à-vis new consumers but do not affect price levels towards old consumers. Markets are overall less tacitly collusive which translates into higher incentives to collude explicitly. Text-mining procedures reveal linguistic characteristics of the communicated content which correlate with market outcomes and communication's effectiveness. The results have implications for antitrust policy, especially for the focus of cartel screening.

JEL Classification: C7, C9, L13, L41

Keywords: Switching Costs, Cartels, Collusion, Experiments.

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1 Introduction

Consumer switching costs play a crucial role in major competition policy cases, especially for market definition and the assessment of market power.[1] Firms use either consumers' inherent or strategic costs of switching to protect their product aftermarkets or create barriers to entry.
Further, they affect firms' price incentives in a twofold manner. Consumers for whom it is costly to switch are less price elastic and are therefore targeted by firms' higher prices. On the other hand, this prospect facilitates competition for consumers who have not bought yet and creates a downward pressure on prices that may compensate consumers in advance. This state dependent pricing pattern is often referred to as "invest-and-harvest" behavior whose composite effect on prices is seen as ambiguous (Klemperer, 1995).
Firms' market power over locked-in consumers and the potential for consumer harm depend also on the level of competition prior to consumers' lock-in (Farrell and Klemperer, 2007). It is increasingly important to account for this state dependency in form of locked-in and not locked-in consumers if firms can indeed price discriminate between the two consumer groups. Neglecting this can lead to an erroneous attribution of high "harvesting" prices to tacit collusion when firms are in fact acting non-cooperatively (Che *et al.*, 2007). Hence, it is increasingly difficult to infer from observed prices to the competitiveness of a market, let alone to tacit or explicit collusive outcomes. Theoretical studies of Padilla (1995); Anderson *et al.* (2004) find in addition also countervailing effects of switching costs on the sustainability of collusion which make them also an obstacle for market screening and prosecution of cartel agreements.
This paper studies consumer switching costs' effect on firms' price setting behavior in a laboratory experiment under the presence and absence of firms' ability to communicate. I compare levels and distributions of prices within a 2x2 experiment design and assess the twofold pricing incentive's effect on the degree of tacit collusion defined in the way of Ivaldi *et al.* (2003) as the mark-up on equilibrium profits. Firms engage in repeated duopolistic Bertrand competition with homogeneous goods, an environment which is seen as favorable for tacit collusive agreements in the literature (Dufwenberg and Gneezy, 2000) and by the European Commission (Davies *et al.*, 2011).
The experimental model consists of two-periods and captures two distinct characteristics. First, consumers live only for a finite time, meaning they retire from the

[1] See United States v. Microsoft Corp., 253 F.3d 34.; Ward v. Apple, Inc., No. 12-17805.

market after the second period. Second, firms are able to price discriminate, that is, they can distinguish between consumers who already bought the product and those who did not, but not between own and rival's customers.[2] This framework is especially suited to pursue the research aim for various reasons. For one it ensures the observability of firms' "invest-and-harvest" motive which would vanish if customers would be indistinguishable and firms would set a somewhat consolidated price targeted at both consumer groups.[3] And second, finitely living consumers are admittedly creating end-game effects but do not overweight the "harvesting" motive relative to the time span in which firms can invest in market share. Hence, it is especially consumers' two-period lifetime that ensures symmetry in firms' pricing incentives.[4]

There is a strong case to study consumer switching costs' effect on tacit and explicit collusion in a laboratory environment. The experimenter has complete control over subjects' ability to communicate which allows for a distinct analysis of these outcomes, something economic theory does not incorporate.[5] Further, laboratory experiments can overcome the sample-selection problem the empirical cartel-literature faces (Posner, 1970).

This study contributes to the literature on the competitiveness of markets under consumer switching costs and is the first, to the best of my knowledge, to investigate the effect of firms' "invest-and-harvest" incentives in a laboratory environment with and without explicit communication.

The analysis of the experimental data provides four main results. First, consumer switching costs lead to lower price levels in the model's first market stage, perfectly resembling firms' "investment" behavior, whereas price levels differ not significantly vis-à-vis locked-in consumers. The second result is that communication facilitates firms' coordination on higher prices which is in line with findings of Fonseca and Normann (2012); Cooper and Kühn (2014) who both show that

[2]Gehrig *et al.* (2011) analyze the effects of this history-based price discrimination due to switching costs on market entry.

[3]The model abstracts from any other source of product heterogeneity as this would only weaken the identification of switching cost's effect on prices. Costs of switching a supplier after an initial purchase make goods ex-post heterogeneous in itself. Hence, it would be unclear to which extent treatment effects are driven by the different sources of product heterogeneity.

[4]Markets that are characterized by the above properties are for instance reduced software licenses that are distributed at a discounted price to students or other groups. Once the status as a student voids, a consumer naturally buys a license of a full version only once. This setting translates to any market with finitely living or participating, identifiable consumers in which firms' incentives resemble the "invest-and-harvest" motive. Further examples are age related products like baby or infant products such as toys and diapers. But also banking services, consulting services and other durable goods and their aftermarkets exhibit these features.

[5]On a related topic see Gehrig and Stenbacka (2007) for firms that are not communicating but share customer information under switching costs.

free-form communication is an effective coordination device in dilemma games. However, communication among firms also negates competitive effects induced by switching costs as they neither affect the level nor the distribution of prices if firms are in fact communicating. Third, switching costs induce distributional effects. Firms' prices towards consumers who have not bought yet are more concentrated at marginal cost level. Further, the price distribution of firms who serve all consumers in the first market stage exhibits a lower variance in the second market stage. Those firms harvest their customer base through prices in close proximity to the static Nash-equilibrium. The fourth result is that switching costs dampen the scope for tacit collusion as firms' supra-competitive profits are significantly reduced. On the other hand the profit gains from communication are more pronounced making explicit conspiracies more attractive. Additionally, the application of text-mining procedures suggests that the amount of noncommittal language used in subjects' communication limits the effectiveness of the communicated content.

The concept of consumer switching costs and their associated effects have been extensively studied in the theoretical literature. Despite the success of models that include a finite time horizon and identifiable consumer groups (see Klemperer, 1995, 1987b), they often fail to give an unambiguous intuition on the overall competitiveness of switching cost markets. Therefore, many studies withdraw from this binary state dependency and turn to infinite time horizon frameworks to particularly avoid end-game effects and provide predictions for a market steady state (see Beggs and Klemperer, 1992; Padilla, 1995; Dubé *et al.*, 2009). Beggs and Klemperer (1992) investigate duopolistic competition under constant consumer entry and exit in every period. They find that markets are less competitive if switching costs are large enough such that consumers are perfectly locked-in to their initial suppliers. Padilla (1995) relaxes this restrictive assumption but nevertheless finds a relaxing effect on competition. However, a more recent approach of Dubé *et al.* (2009) challenges this view and shows a negative effect of consumer switching costs on prices while also allowing for imperfect lock-in. Hence, switching costs' overall competitive effect remains ambiguous independent of the model's time horizon.

2 The Model

The experimental model is based on the theoretic framework of Klemperer (1995, Section 3.2) and incorporates a finite time horizon in form of two subsequent market stages in which switching costs emerge only in the second stage, representing the "mature" market. In our implementation, firms engage in duopolistic Bertrand competition for market shares and do not discount profits from the second stage. We denote $\pi_k^i(p_k^i, p_k^j)$ for $k = 1, 2$ as firm i's profit in market stage k.[6] Goods are produced at constant marginal cost c in both stages. Consumer mass is of size m and exhibits inelastic unit demand of one up to a reservation price of $p^{max} > 0$. After their initial purchase in $k = 1$ consumers face switching costs of S in case they switch suppliers in $k = 2$.

Switching costs are not too large such that consumers are only imperfectly locked-in. This feature is important in order to preserve firms' pricing incentives in $k = 2$, in the sense that a firm can still induce consumer switching if it chooses to price aggressively (see Padilla, 1995; Dubé *et al.*, 2009). We therefore impose the following assumption.

Assumption 1. *We assume consumer switching costs to be positive and of intermediate size such that* $\frac{p^{max}-c}{4} \leq S \leq \frac{p^{max}-c}{2}$.

Consumers are myopic and maximize their single market stage utility.[7] Hence, they buy whatever product is cheapest to them, also considering potential costs of switching. If consumers are indifferent, their demand is split up equally among the two firms. A firm i's profit function is displayed in Appendix A.

We can identify three distinct subgames for $k = 2$. Two of previous monopolization, by the rival or a firm i itself, and one subgame in which firms shared market demand equally beforehand.

2.1 Monopolization

Given that a firm i was able to monopolize the market in $k = 1$, it will either keep its market share, lose one half of it, or lose it entirely in $k = 2$. We can formulate equilibrium prices and profits as follows.

Proposition 1. *Let* $p_1^i < p_1^j$. *Then, in the subgame perfect Nash equilibrium, a firm* i *also*

[6] Note that $\pi_k^i(p_k^i, p_k^j)$ is a step function and not continuously differentiable in firms' prices.

[7] See also Klemperer (1987a) for a discussion of switching costs under different levels of consumer expectations and future tastes.

monopolizes the market in $k = 2$ under prices of

$$p_2^{i^{MI}} = p_2^j + S = c + S; \quad p_2^{j^{MI}} = c\,, \tag{1}$$

and profits of

$$\pi_2^{i^{MI}} = S \cdot m\,; \;\; \pi_2^{j^{MI}} = 0. \tag{2}$$

Proof. See Appendix B.[8] □

Intuitively, a firm i who previously served the entire market demand will set a price (just below) $p_2^i = p_2^j + S$ that maximally exploits its own customer base while securing not to lose any market share over to its rival. Given this pricing strategy, any rival's price of $p_2^j > c$ implies a profitable deviation for firm j as it can profitably attract at least some demand if it lowers its price.

2.2 Equal split

If firms set identical prices in $k = 1$ they are endowed with a symmetric customer base entering competition in $k = 2$. As a consequence they face a trade-off between harvesting their existing customer base with a price of (just below) $p_2^i = p_2^j + S$ or undercut a rival's price with (just below) $p_2^i = p_2^j - S$.[9] We find an equilibrium in mixed strategies of the following form.

Proposition 2. *Let $p_1^i = p_1^j$. Then, in the subgame perfect Nash equilibrium, a firm i randomizes in $k = 2$ over two disjoint price sets of*

$$p_2^{i^S} \in \mathbf{A} \dot\cup \mathbf{H}\,, \tag{3}$$

with

$$\mathbf{A} = \left[\frac{p^{max} + 2S + c}{2} - S, p^{max} - S\right] \equiv [\underline{\alpha}, \bar{\alpha}]$$
$$\mathbf{H} = \left[\frac{p^{max} + 2S + c}{2}, p^{max}\right] \equiv [\underline{\epsilon}, \bar{\epsilon}]$$

and earns expected profits of

$$E\left[\pi_2^{i^S}\right] = \left(\underline{\epsilon} - c\right) \frac{m}{2} > \pi_2^{i^{MI}}\,. \tag{4}$$

[8] This is the price equilibrium also shown in Klemperer (1987b, Section 2) and Farrell and Klemperer (2007, Section 2.3.1).

[9] As Farrell and Klemperer (2007, Footnote 31) put it, this setting "generally eliminates the possibility of pure-strategy equilibria if S is not too large".

Proof. See Appendix B. □

The set of $\mathbf{A}$ contains aggressive prices a firm i would set in order to win over the rival's customer base, whereas harvesting prices are part of the set $\mathbf{H}$. This mixed pricing equilibrium is in spirit similar to findings of Padilla (1992); Fisher and Wilson (1995); Shilony (1977) who all find mixed strategy equilibria in single-staged settings with switching costs (or equivalent components). Note that firm i's expected equilibrium profits in the split subgame exceed those from i's monopolization subgame. The symmetric distribution of market shares induces both firms to compete less fiercely for the rival's customer base, contrary to a monopolization subgame. Firms' behavior can be interpreted in terms of two "fat cats" in the sense of Farrell and Shapiro (1988) who do not compete for rival's imperfectly locked-in consumers but rather harvest existing ones. Asymmetric market shares under a monopolization, on the contrary, work as a commitment for the outsider to price aggressively.

2.3 Market stage one & equilibria

Firms maximize combined profits ($\Pi^i = \pi_1^i + \pi_2^i$) from both market stages. Obviously, a firm i does not want to overprice its competitor in $k = 1$, since this implies zero profits in either market stage. Monopolization in $k = 1$ is indeed always profitable from a single period perspective, but it consequences lower profits in the following subgame of $k = 2$ relative to an equal split. Given a rival's price, the trade-off between monopolization and splitting market demand gives rise to the following equilibria.

Proposition 3. *There exist multiple, symmetric, pareto-rankable subgame perfect Nash-equilibria in pure strategies that include first stage prices over the interval of*

$$p_1^i = p_1^j \in \left[2c - \underline{\epsilon}\,;\ \underline{\epsilon} - 2S\right]. \tag{5}$$

Firms realize total equilibrium profits of

$$\Pi^{i^*} = \Pi^{j^*} \in \left[0, \left(2\underline{\epsilon} - 2c - 2S\right)\frac{m}{2}\right]. \tag{6}$$

Proof. See Appendix B. □

Firm i finds it only optimal to monopolize if it can do so at a relatively high price, that is above the interval stated in (5), such that monopolization profits in $k = 1$ are substantial and make up for fiercer competition in the subsequent subgame.

However, this is naturally not feasible in equilibrium as the rival could profitably deviate. These equilibria are in line with results of Suleymanova and Wey (2011) who also find a market sharing equilibrium in Bertrand competition under switching costs.

3 Experimental design

Experimental markets consist of $m = 30$ consumers that buy one product up to a reservation price of $p^{max} = 100$. The symmetric duopolists face constant marginal cost of production of $c = 40$. A firm is able to single-handedly serve all consumers in the market. Firms choose prices simultaneously and independently from the continuous action set $p^i_k \in [0, .., 100]$.
The 2x2 design consist of four treatments in total. In N20 (No communication with Switching Costs) and T20 (Talk with Switching Costs) switching costs are of size $S = 20$. Whereas in N0 and T0 they are of size $S = 0$. Subjects are able to communicate in treatments T20 and T0.

Table 1: Treatment overview

	$S = 20$	$S = 0$
No Communication	**N20**	**N0**
Communication	**T20**	**T0**

A playing period consists of one iteration of the static game and is played repeatedly.[10] In each of the treatments subjects played a total of three supergames. Subjects were randomly re-matched to a stranger between each supergame. This between subjects design is especially robust against anticipated learning effects. Subjects play more repetitions of the same treatment while the treatment comparisons separately by supergame account for supergame specific effects. The length of a supergame was determined by a random termination rule, proposed by Roth and Murnighan (1978), for which Fréchette and Yuksel (2013) show that it induces the highest cooperation rates compared to other termination methods in repeated prisoners' dilemma interactions. The incorporated continuation probability was 0.875.[11] Supergame lengths were determined ex-ante and were constant over all

[10]See Appendix C on the infinitely repeated switching cost game.

[11]The continuation probability of 0.875 secures that coordination on any price is a collusive equilibrium of the repeated game if firms punish according to a Nash-reversion trigger. Multiple equilibria and the two market stages of the static game provide varying punishments and deviation timings in the indefinitely repeated game. However, for each punishment-deviation pair a

treatments. The first supergame lasted for 6 playing periods, the second for 12 periods and the third for 5 periods.

In T20 and T0, subjects were able to communicate for a duration of 120 seconds prior to each supergame via an instant-messenger tool. There was no communication during supergames such that we can perfectly abstract from renegotiation effects. The time limit was sufficiently long to communicate experiment relevant information and subjects were allowed to post as many messages they liked during that time span. Hence, communication was in free-form, which is seen as one of the least restrictive and therefore most effective in facilitating coordination in dilemma games (see Crawford, 1998; Brosig *et al.*, 2003). Subjects were aware that they communicated only with their rival and not to other participants.

Each treatment was conducted in a separate session with 24 participants. Instructions were handed out in written form and subjects answered additional control questions on their computer screen prior to the experiment. Price and text inputs were made via a computer terminal and feedback was given after each market stage on current own and rival's prices, own profits and the resulting consumers' purchasing decision.[12] Additionally, they had information on their own accumulated profits but not on their rival's. Furthermore, subjects' user interface included a profit calculator, which was accessible in all treatments.

Sessions were programmed in z-Tree (Fischbacher, 2007) and were run at the DICE Lab at the Heinrich-Heine University of Düsseldorf in which a total of 96 students participated. Subjects were awarded with a show-up fee of €4 and earned an "Experimental Currency Unit" called "Taler" with an exchange rate of 3,000 Taler : €1. Subjects were payed their cumulative earnings of all supergames. Potential losses were offset against the show-up fee and average payment was €16.03 and session duration reached from 50 up to 70 minutes.

4 Treatment effects

This section reports quantitative results regarding switching costs' and communication's effect on prices, profits and the competitiveness of markets. Prices enter the analyses as posted by subjects and conducted tests are all non-parametric. Test statistics are computed separately over supergames and are based on market level

continuation probability of 0.4 is sufficient to secure collusive equilibria. Experimental studies of Bó (2005); Fréchette and Yuksel (2013) provide evidence that the continuation probability indeed affects cooperation rates in dilemma games.

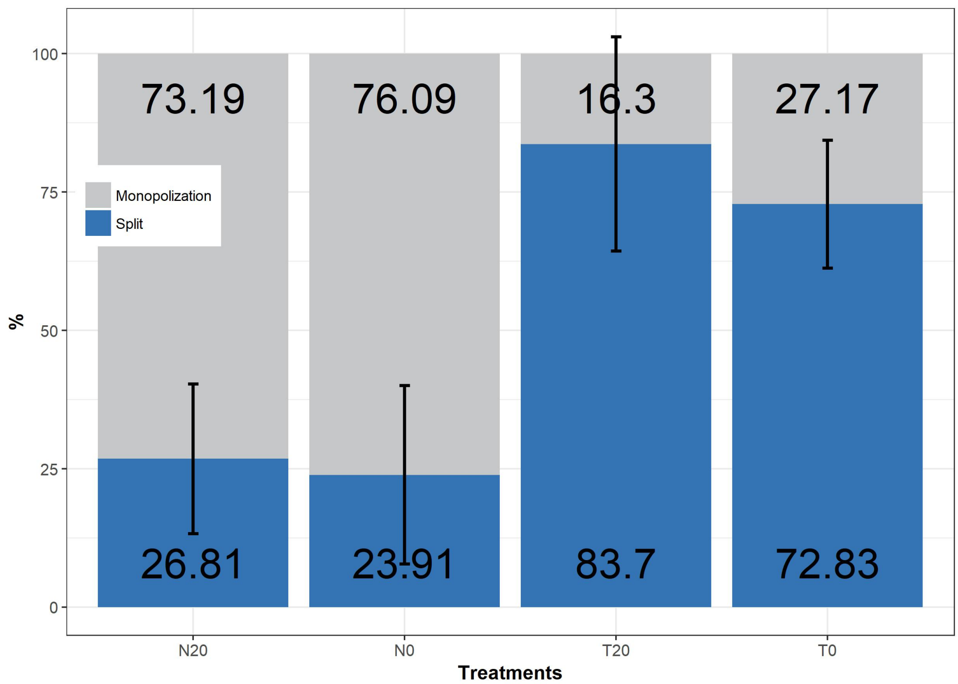
[12]For feedback induced effects on collusion in Cournot markets see Gomez-Martinez *et al.* (2016).

data.

4.1 Market states

Coordination on identical prices is naturally easier if one can communicate. Hence, states in which a market is monopolized by either of the two firms should be less frequent if firms indeed talk. We observe this also in the data since market demand is split equally in 83.7% in T20 and 72.8% in T0 (see Figure 1). If firms cannot communicate coordination becomes much more difficult to the effect that the fraction of splits shrinks to 26.8% (23.9%) in N20 (N0).

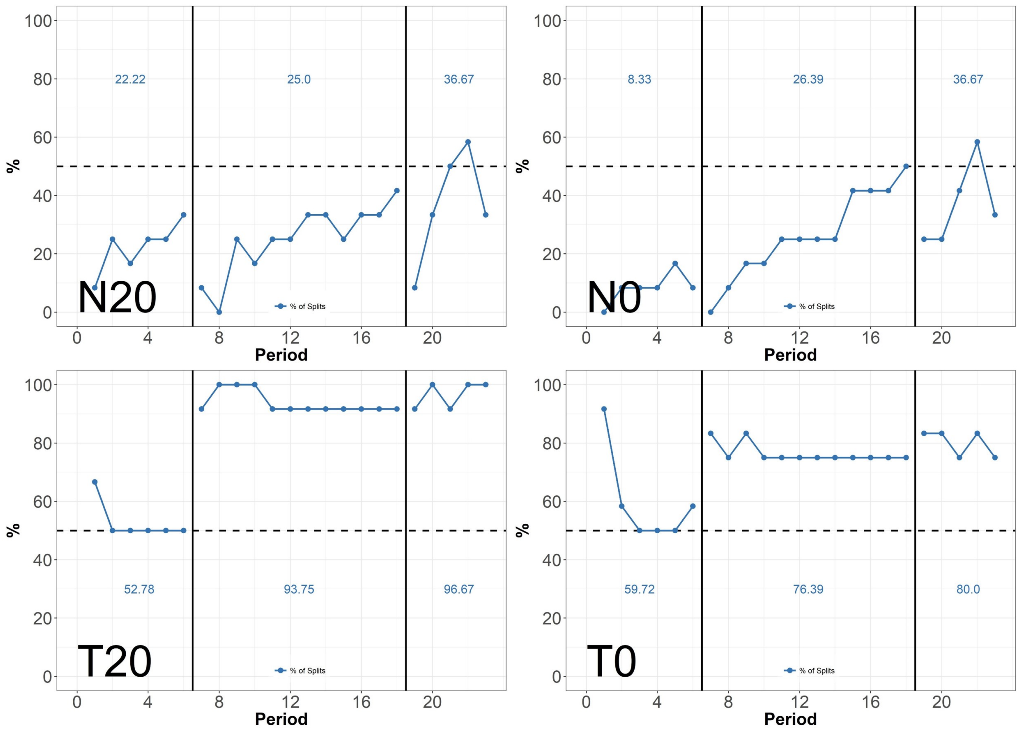
Figure 1: Market state proportions



Notes: Fractions of markets being monopolized or split by treatments. Error bars display the $-\sigma/+\sigma$ area based on market level variation.

However, talk-treatments differ not only in average market state proportions but also in their development over time. If firms communicate, market states of a split are frequent and stay virtually constant over the course of each supergame. The only exception to this are the respective first supergames. Here, coordination indeed starts at a high frequency but breaks down rapidly after the first period of play (see Figure 2). Whether this could be driven by subjects' communication will be discussed in Section 5. If firms cannot communicate however, market splits seldom occur at the start but become more frequent over the course of each supergame in N20 and N0. This process culminates up to parity of market states

Figure 2: Timetrends of market splits



Notes: Observed frequencies of market sharing are displayed over the course of each supergame. Annotations provide average empirical probability of occurence for a market sharing outcome.

in the second supergame, and even to a majority of splits during the third. The above stated observations can not be accounted to the presence of switching costs. Neither constant market state frequencies if firms communicate nor increasingly frequent market splits if they do not talk are different when conducting the treatment comparisons of T20-T0 and N20-N0.

The cause for market splits becoming gradually more frequent in N20 and N0 can be twofold. Either this is driven by an increasing number of markets that manage to coordinate on an identical price and sustain it once they reach it, or by markets on which market states alternate and splitting market demand becomes just more frequent. Both possible explanations should be reflected in first order Markov transition matrices which are shown in Table 2.

Table 2: Market state transition matrices in N20 and N0

N20	to Split	to Monop
from Split	**67.21%**	**32.79%**
from Monop	**16.76%**	**83.24%**

N0	to Split	to Monop
from Split	**80.0%**	**20.0%**
from Monop	**10.27%**	**89.73%**

We observe that in both treatments probabilities along the main diagonal are quite

large. Hence market states are rather recursive and the likelihood of observing the same market state on a specific market repeatedly is high. To be precise, market demand is repeatedly split in 67% in N20 and 80% in N0 while repeated monopolization occurs in 83% and 90%. Aside from almost a third of all splitted markets in N20 that move towards monopolization (33%) the next period, transitions between market states are less frequent and overall mobility is low.
Firms on not-moving markets are either satisfied with the status quo or want to move but find it difficult to do so. Transition difficulties should however only be an issue if firms want to coordinate on an identical price originating from monopolization. If the market is already split however, firms usually can unilaterally alter this in charging any price other than the previous one (profitably a lower one). Thus, we generally deduce that firms find it indeed profitable to split market demand in the first market stage and compete within a symmetric market environment in $k = 2$.
Since the empirical transition matrices are both aperiodic and irreducible there exists a stationary distribution of market states. These distributions can be characterized as long run steady states if market state transitions behave as in Table 2. These ergodic distributions for N20 and N0 are displayed in Table 3. Hence,

Table 3: Stationary distributions in N20 and N0

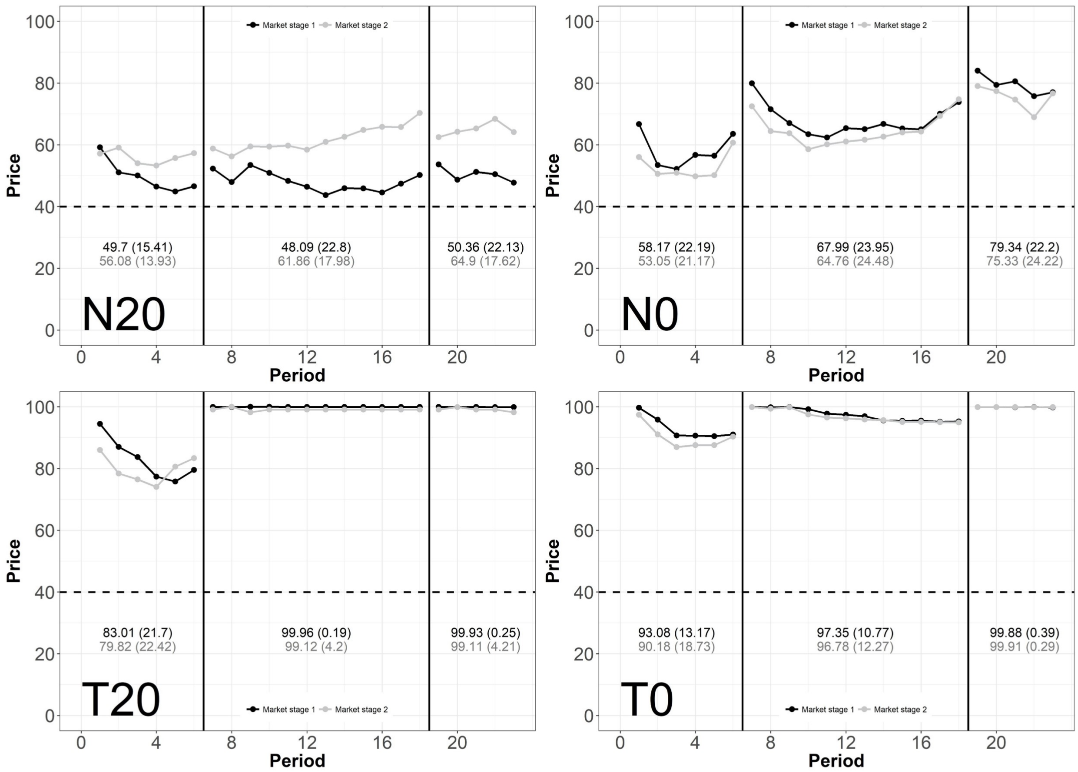
N20	Split	Monop	**N0**	Split	Monop
	33.82%	**66.18%**		**33.93%**	**66.07%**

in the long run a firm will split market demand in 33.82% of all cases in N20 and 33.92% in N0. Again, the presence of switching costs seems to have no influence on the long run distribution of market states.

4.2 Price level

Our first main result stems from the pairwise comparison of mean prices and subgame specific price levels of treatments N20 and N0. Figure 3 displays the development of mean market stage prices over the supergames. Mean prices in $k = 1$ are significantly lower in N20 compared to N0 (two-sided Wilcoxon-Mann-Whitney U (WMW), all supergames $p < 0.05$). This downward pressure on prices is not only an aggregate effect but is present in all subgame dimensions. Price levels at which the market is split, monopolized and price levels of firms who are undercut, are all significantly lower (WMW, all $p < 0.01, 0.01, 0.05$). Figure 4 shows subgame specific prices in non-communication treatments. Firms' "invest-

Figure 3: Mean prices by treatments



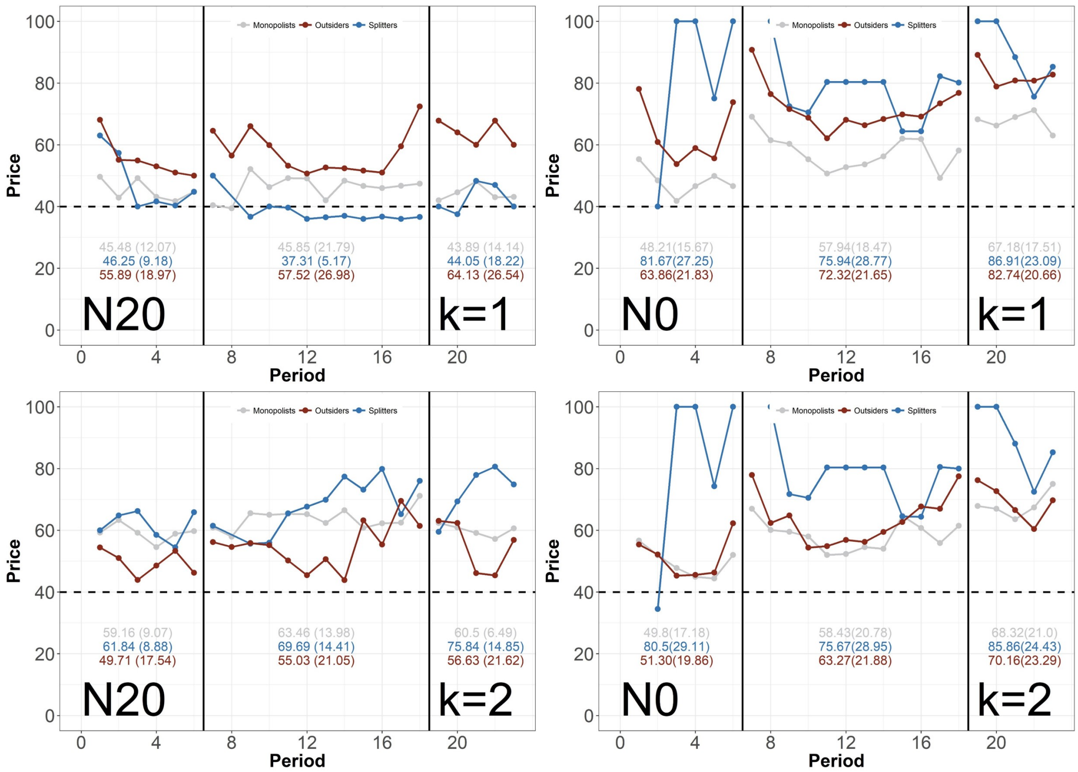
Notes: Mean prices in each market stage and period of play for all treatments and across all different subgames. Black data points correspond to prices of the first market stage ($k = 1$), while grey data correspond to the second ($k = 2$). Annotations provide mean supergame prices (standard deviations based on market averages in parenthesis).

ment" motive in N20 is especially pronounced in monopolists' mean prices who just price above marginal cost and splitters' who even price below that threshold in the second supergame. If switching costs are zero however, firms who coordinate on identical prices do so at prices which even exceed those of outsiders who overprice their fellow competitors.

Firms do invest in $k = 1$ of N20 and also raise prices in $k = 2$. This is especially true for monopolists and even more for firms that shared market demand beforehand, while outsiders who initially overpriced adapt prices downwards. However, mean prices in $k = 2$ (towards locked-in consumers) are not significantly different compared to N0 (WMW, all $p > 0.1$). If switching costs are absent monopolists and splitting firms price almost identically as before and only outsiders decrease prices. Further, prices follow a stepwise upward trend over supergames implying a positive restart effect which we do not observe in N20.

Result 1 *In N20, switching costs induce firms to sell at lower prices in $k = 1$ but the price level towards old consumers ($k = 2$) is not different from those of N0.*

Figure 4: Mean prices for non-communication treatments by subgames



Notes: Mean prices in each subgame and period of play for non-communication treatments. Data points in grey, blue and red correspond to prices of monopolists, splitters and firms who have been undercut in $k = 1$ respectively. Annotations provide mean supergame prices in each subgame (standard deviation based on market averages in parenthesis).

The pairwise comparison between N20 and T20 as well as N0 and T0 produce our second result. We find strong evidence that communication increases firms' ability to sustain a higher price level (WMW, all $p < 0.01$). Although we observe prices significantly declining in the first supergame of either communication treatment (see. Figure 3), free-form multilateral communication is still effective. Further, switching costs' effect on the price level vanishes if firms are in fact communicating as levels are not significantly different in T20 and T0 (WMW, all $p > 0.243$). This holds for prices across subgames as well as sugame specific prices. Thus, communicating duopolies seemingly manage to overcome competitive effects caused by switching costs.

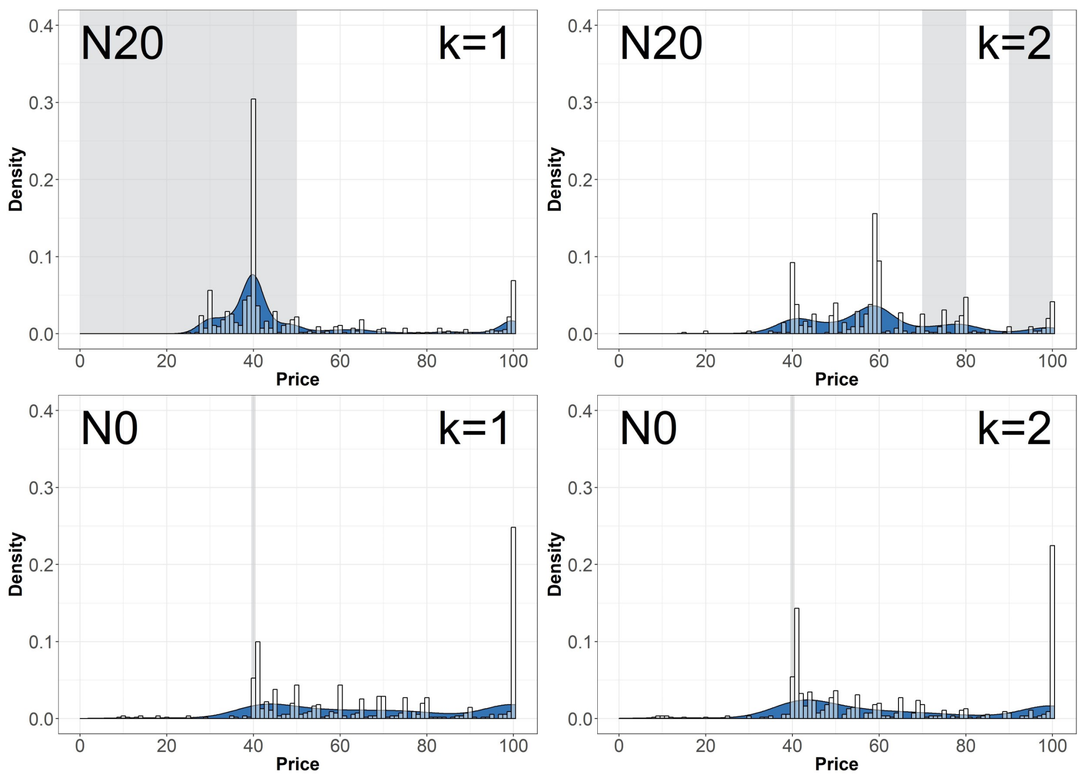
Result 2 *Price levels are higher if firms can communicate. Switching costs have no competitive effects if firms are communicating.*

4.3 Distributional characteristics

Although switching costs have no significant effect on the price level in $k = 2$, that is the price level faced by locked-in consumers, they do seem to have an effect on the variance of posted prices in N20 and N0. Standard deviations for monopolists' prices and those on shared markets are reduced if switching costs are active (see Figure 4). Possibly, switching costs' effect on firms' price setting behavior is simply not fully captured by a rank based statistic and is rather characterized by higher moments of the observed price distribution than just the first.

Our third result is derived by comparisons of empirical CDFs and estimated kernel densities (KDE). The observed price distributions in treatments T20 and T0 are virtually identical and feature the bulk of probability mass on p^{max} (Figure D.1). Switching costs have no effect on firms' price distribution if communication is active such that we restrict the following analysis to the non-communication treatments N20 and N0. Figure 5 displays the empirical distribution of all posted prices in non-communication treatments and the corresponding KDEs.

Figure 5: Price distributions in N20 & N0 with KDEs

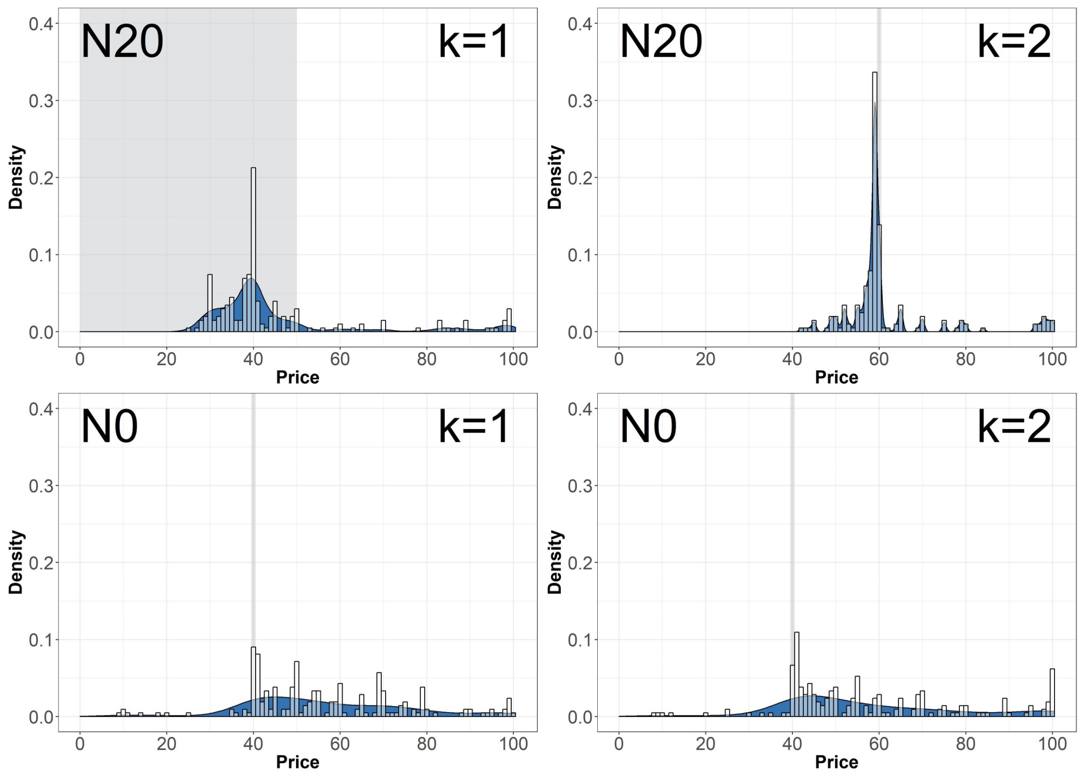


Notes: Displayed distributions incorporate posted prices in all supergames and across all subgames. Grey highlighted areas correspond to prices of the subgame perfect Nash-equilibrium of the static game. Kernel densities are estimated via the Gaussian Kernel function and bandwidth is one standard deviation of the kernel.

Switching costs' effect on price distributions in $k = 1$ is two-fold. First, firms post

less prices at p^{max} (6.9%) in N20 whereas it accounts for the highest probability mass (24.5%) in N0. Second, prices are more concentrated around marginal costs of $c = 40$ with 60.5% of observations even smaller or equal to that threshold. In N0 prices are more uniformly distributed above marginal cost level (only 8.7% price such as $p \leq 40$). These distributional differences are significant on a market level (Kolmogorov-Smirnov (KS), all p-values < 0.01). The concentration of probability mass around marginal costs is even more pronounced if we filter for prices at which the market is successfully monopolized (Figure 6) and shared (Figure 7).
In N20, monopolists invest in a high market share with 25.2% of prices close to marginal cost level ($p \in [40, 41]$) and even 43.6% below cost. In contrast to this, monopolists in N0 price only in 17.1% of all cases according to the static Nash-prediction within $[40, 41]$ but manage to monopolize the market with prices above this threshold (81.3%) (KS, all $p < 0.1$). If we consider shared markets, we identify

Figure 6: Monopolists' price distributions in N20 & N0 with KDEs

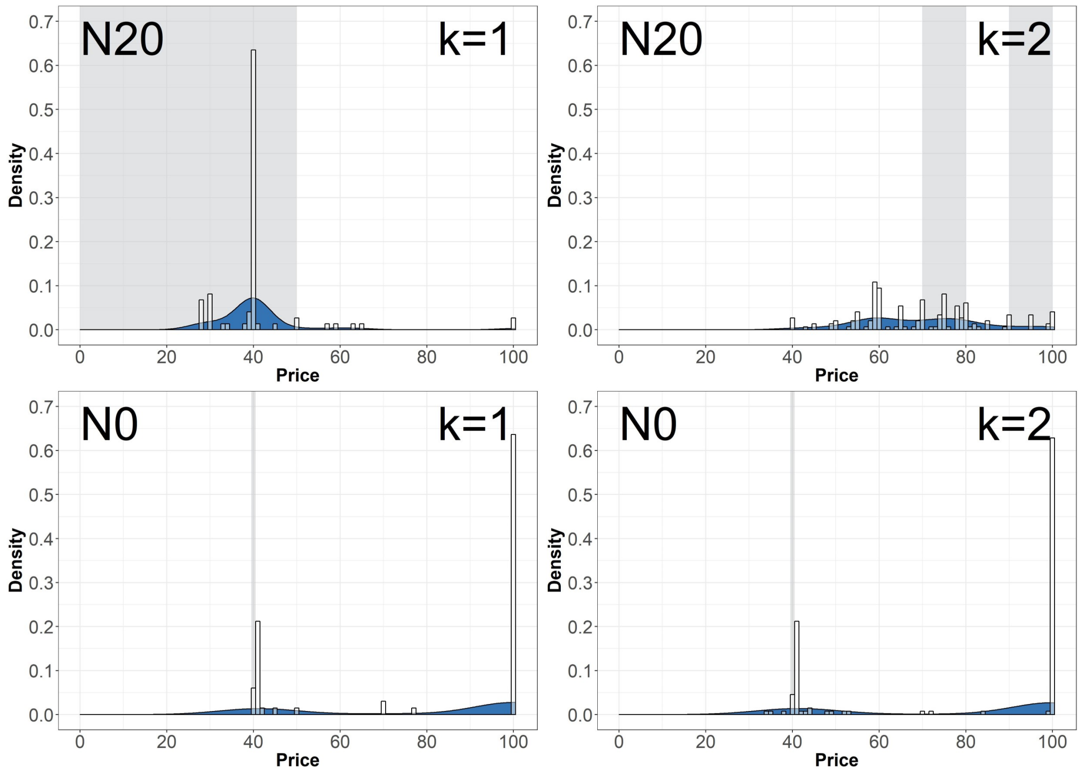


Notes: Displayed distributions incorporate posted prices in all supergames of firms who monopolize the market in the first market stage. Grey highlighted areas correspond to prices of the subgame perfect Nash-equilibrium of the static game. Kernel densities are estimated via the Gaussian Kernel function and bandwidth is one standard deviation of the kernel.

a price of $c = 40$ as a focal point for coordination (63.5%). An additional 23% of all splits occurred at prices even below c. This pricing pattern is significantly different (KS, all $p < 0.01$) to shared markets under absent switching costs which are either

increasingly collusive at p^{max} (63.64%) or competitive at $p \in [40, 41]$ (27.27%).
In $k = 2$ of N0, firms price almost as identical as in the first market stage. Distributions of prior monopolists and also firms who previously split market demand exhibit no significantly different pricing patterns. The only exception are firms who initially served no demand and adapt their prices downwards. Their KDE exhibits now more probability mass on lower prices and resembles more closely the distribution of prior monopolists' (see Figure D.2). In N20 however, we identify a trimodality in the KDE across all subgames which we do not observe in competition for new consumers (Figure 5). We identify its concentrations in proximity to $p = 40, 60, 80$ as a composite effect that corresponds to the pricing incentives in the three different subgames of $k = 2$.
Prices of $p \in [59, 60]$ are frequently chosen by monopolists who price according to the static Nash-prediction (Figure 6). Precisely, 47.5% of all monopolists, price in this interval and even 80.2% choose a price of $p \leq 60$. Given a rival's rationality, the majority of monopolists therefore effectively harvest their locked-in customers while not loosing demand over to its rival. If switching costs are absent however, only 18.3% of prior monopolist choose a price of $p \in [40, 41]$ which would correspond to static equilibrium play. We find the distributional differences to be significant (KS, all $p < 0.1$). Additionally, the condensing of probability mass is also reflected in lower variances in all supergames (Fligner-Killeen, all $p < 0.05$). This however may have implications for cartel screening in antitrust policy. Screens often take small variances as signal for potential cartel activities (Abrantes-Metz *et al.*, 2006). Switching costs could then lead to an increased number of false positives whereas firms are in fact acting competitively.
Monopolists' virtually optimal play, in terms of game theory, coincides with the pricing behavior of firms that were previously driven out of the market (see Figure D.2). 33.66% of these firms price indeed such as $p \in [40, 41]$ and are restricting the monopolist maximally while securing themselves a non-negative payoff in case they win over some customers. The majority (56.93%) prices above that corridor following no systematic pattern. However, outsiders' price distributions in N20 are not significantly different from those of N0.
While KDEs for monopolists and outsiders are unimodal, shared markets exhibit a bimodal estimate. Probability mass agglomerates around values of $p = 60, 80$ (Figure 7) and corresponds to maxima of the KDE across all subgames. 62.2% of market sharing firms choose prices of $p > 60$ in $k = 2$ and therefore price higher as the vast majority of monopolists. Apparently, subjects notice a rival's increased opportunity costs if both firms are equipped with an existing customer

Figure 7: Splitters' price distributions in N20 & N0 with KDEs



Notes: Displayed distributions incorporate posted prices in all supergames of firms who shared market demand in the first market stage. Grey highlighted areas correspond to prices of the subgame perfect Nash-equilibrium of the static game. Kernel densities are estimated via the Gaussian Kernel function and bandwidth is one standard deviation of the kernel.

base. However, the observed bimodality does not coincide with the two disjoint price sets of the static Nash equilibrium in mixed strategies. Although KDEs for shared markets visually look very different in $k = 2$ of N20 and N0, differences are statistically not significant.[13]

Result 3 *In N20, switching costs cause firms' price distribution in $k = 1$ to be more concentrated at marginal cost level ($p_1 \in [40, 41]$) while they induce monopolists to price in closer proximity to the static equilibrium price level in $k = 2$ compared to N0.*

4.4 Competitiveness & Collusion

The competitiveness of a market and hence its scope for collusion is mainly determined by the profits firms are able to realize. Given that the demand specification

[13]Since we do not observe split subgames on every market in every supergame the statistical test is performed on a reduced sample size. We observe Split subgames in N20 on 8 markets in the first supergame, 9 in the second and 8 in the third. In N0 we observe 3,9 and 8 markets that exhibit split subgames.

of the underlying model secures cleared markets, firms' profits are only driven by selling prices. Although treatment effects are based on posted prices, our first two results with respect to the price level carry over to the profit dimension as can be seen in Table D.2.

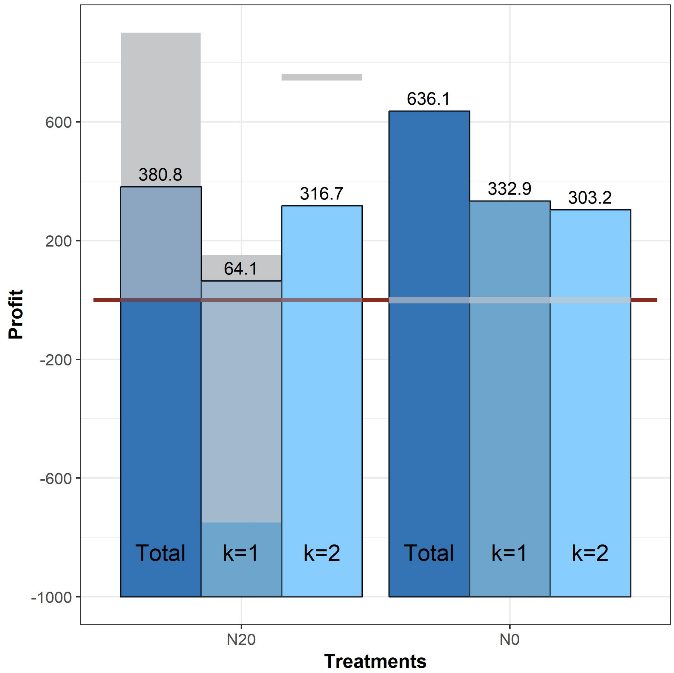
Firms earn significantly less in $k = 1$ of N20 whereas profits in $k = 2$ are equivalent to those of the reference market (N0). Apart from this we observe differences in profits for monopolists and outsiders between both communication treatments. However, these can be explained by subjects' choice of coordination strategy. [14]

From these we can now infer the competitiveness of switching cost markets. Especially to answer the question whether profits are realized competitively or whether the market environment is rather tacitly collusive? As Ivaldi *et al.* (2003, p.5) put it "..., tacit collusion is a market conduct that enables firms to obtain supra-normal profits, where 'normal' profits corresponds to the equilibrium situation...". We therefore measure the intensity of tacit collusion as the amount of profits that exceed the static Nash-equilibrium level. Following this notation a profit around the equilibrium level would not be collusive whereas a negative equilibrium mark-up would indicate a somewhat over-competitive environment. We exploit the variation in firms' supra-competitive profits to evaluate switching costs' effect on the market's competitiveness. For this, Figure 8 displays firms' mean and equilibrium profits of one playing period in the non-communication treatments.

In N0, firms manage to establish a tacit collusive environment in either market stage. If switching costs are active however, firms manage to realize profits that are for one below the mixed strategy equilibrium profit in $k = 2$ and for another within the set of equilibrium profits of $k = 1$. Hence, profits from locked-in consumers under switching costs are rather realized competitively as the tacit collusive intensity is significantly lower (WMW, all $p < 0.01$). We cannot provide such clear cut evidence for the competitiveness of the markets in $k = 1$ as it depends on the choice of a competitive reference point within the set of equilibrium profits. If we take the upper interval profit as reference we assume a somewhat "friendly" competitive benchmark and find evidence that also supra-competitive profits from new consumers are significantly lower (WMW, all $p < 0.01$). If the median or lower bound profit of the interval are taken as reference, intensity of tacit collusion either does not differ or is significantly higher (WMW, all $p < 0.1$).

[14] In T0 more subjects adapt a collusive strategy of alternating monopolization (take-it-in-turns) rather than coordinate on an identical price. Additionally, a firm who applies this strategy and monopolizes the market in the second stage in T20 has to undercut by a high margin whereas in T0 already a marginally lower price is sufficient. Outsiders' profits in T0 are therefore lifted upwards.

Figure 8: Mean and equilibrium period profits in N20 and N0



Notes: Profit bars display firms' mean period profits in each market phase. Grey shaded areas correspond to profits of the subgame perfect Nash equilibria of the particular game.

Switching costs' effect on the total level of tacit collusion, that is over both market stages, is however unambiguous as we find strong evidence that firms realize less supra-competitive profits if we take the median equilibrium profit as reference (WMW, all $p < 0.01$). Even if we assume equilibrium profits of fierce competition (lower interval border) we find the degree of tacit collusion to be lower in the third supergame of N20 (WMW, $p < 0.05$).

However, the question why firms are not able to establish a comparable degree of tacit collusion, although higher profits can be sustained even in the static equilibrium, remains puzzling. Seemingly, consumer switching costs induce firms to behave more competitively in general, whereas the atmosphere is more cooperative in N0. The prospect of looming asymmetries and the opportunity to gain a competitive advantage could drive the perception as rivals between the duopolists whereas firms being symmetric throughout contributes to a more cooperative view of the fellow duopolist.

The presence of unexploited tacit collusive potential under switching costs is most pronounced in $k = 2$. Splitters could price more bravely at higher prices given symmetric customer bases while monopolists almost perfectly settle for safe equi-

librium profits rather than trying to establish a tacit collusive outcome above equilibrium level. Opportunities for monopolists to do so are plenty however, as outsiders do not maximally restrict the monopolist in most of the cases and charge prices above marginal cost (56.93%). On the other hand, outsiders also have an incentive to raise a monopolist's profits since market interactions take place repeatedly and one time outsiders become monopolists themselves eventually.
This good news in terms of consumer harm however should also influence a firm's decision in the field whether to form a cartel and collude explicitly. Naturally, a limited scope for tacit collusion makes the prospect of high profits under explicit collusion even more attractive. As Shapiro (1989, p.357) puts it "Anything...that makes more competitive behavior feasible or credible actually promotes collusion". Hence, consumer switching costs should also make explicit collusion more attractive. A realistic way to measure a firm's incentive to collude explicitly is the profit it would gain through such an agreement. Fonseca and Normann (2012) therefor assess profit differences between communication and non-communication treatments. In a difference-in-difference OLS-regression (Table D.1) we find indeed that in supergames two and three the increase in firms' profits under communication is more pronounced if switching costs are active. Hence, firms would profit more from communication and have a stronger incentive to collude explicitly. The contrary result in the first supergame can be mainly explained by subjects' inexperience and a lower price level in T20 relative to T0. Hence, consumer switching costs on the one hand reduce the scope for tacit collusion while on the other hand they may make profits from explicit cartel agreements even more attractive.

Result 4 *Consumer switching costs reduce firms' supra-competitive profits and therefore the intensity of tacit collusion. On the other hand, after some learning, gains in profits from communication are more pronounced making explicit agreements more attractive.*

In the field this trade-off between tacit and explicit collusion should be highly relevant as firms who cartelize coincidentally reject the option to collude tacitly. Hence, consumer switching costs could not only facilitate competition but also make markets more susceptible to cartel agreements. Our results suggest that firms' "investment" incentive towards consumers who have not bought yet may be more pronounced than "harvesting" the mature market. The competition for those consumers may therefore be more crucial for a firms' potential cartelization decision. Industries in which new consumers initially buy at relatively high prices although a subsequent switch of suppliers is costly, could indicate the existence of potentially dominant firms or firms who behave anti-competitive. Hence, an increased focus on switching cost markets and especially competitively "soft" investment stages for cartel screening could be promising. If firms do not communicate however, the experiment data suggests that switching costs indeed induce firms to invest in customer bases and harvest them later on, but also that the overall scope for consumer harm is reduced.

5 Text Analysis

The analysis in this section covers the second dimension of input subjects made during the experiment, that is chat content. We employ different approaches and metrics to quantify communication among subjects which contain descriptive statistics based on unsupervised message counts as well as text mining procedures. These results accompany findings of the prior quantitative analyses and should not be interpreted as causal relationships. We are primarily interested in whether communicated content differs in the presence of switching costs and even more so between the first supergame and the latter two of the respective treatments since these exhibit differences in distribution of market states and the price level.

5.1 Descriptives

In this section we provide descriptive statistics assessable by simply counting *messages* in the raw, unsupervised chat log.[15] We define a *message* as a line of text that is written by subject i and is sent coherently to subject j within an experimental market. Therefore, a message is interpreted as an unilateral contribution to the within market communication. Table 4 displays mean message counts within a market for each supergame ($\overline{C}_{SG}$) and treatment. While we observe more overall interactions between duopolists in T0, the number of messages sent per supergame increases over the course of the experiment in both treatments. Especially in T0 chat interactions become more frequent after the first supergame. In the light of the market outcomes in the first supergame of both communication treatments,

[15]The text data is unsupervised in the sense that neither punctuation and misspellings are corrected nor are *stopwords* filtered out. Stopwords are language specific and include words that are naturally used very frequently while not bearing any analytic value for the specific research question. For the English language these can be "a", "and", "also" or "the" among others. They are usually removed prior to text mining procedures in order to avoid any bias.

Table 4: Mean messages per market and supergame

Means of within market *messages*	T20	T0
$\overline{C}$	**12.83**	**14.5**
$\overline{C}_1$	10.75	11.5
$\overline{C}_2$	12.58	15.25
$\overline{C}_3$	15.17	16.75
Observations	462	522

the lower amount of messages seems not surprising. Possibly subjects' communication was simply not extensive enough to establish stable collusion.

5.2 Text Mining

Whereas simple message counts only display how reciprocal a conversation might be, text mining methods allow a somewhat objective analysis of the communicated content. Based on our quantitative findings of Section 4 we are particularly interested whether communicated content differs between treatments and even more so whether content can indicate why collusion breaks down so frequently in the first supergame compared to supergames two and three.
For this purpose we use the *Relative Rank Differential* (RRD) of Huerta (2008) which measures words that are relatively more frequent in one corpus of text compared to another.[16] Text mining methods so far have been mostly used in fields of computational linguistics and health sciences but recently also for the analysis of chat content in economic experiments (Möllers *et al.*, 2017).
The RRD statistic is calculated on word ranks according to their frequency in the respective corpus. For the ordinal measurement of words within a corpus we adopt the fractional ranking method ("1 2.5 2.5 4") for the RRD which is calcu-

[16]The compared corpora of text however do not necessarily correspond to text of different treatments but can also capture subsets of different market outcomes or other dimensions. In our case the respective first supergame and supergames two and three.

lated according to (7).[17]

$$RRD_{w,t1} = \frac{r_{w,t2} - r_{w,t1}}{r_{w,t1}} \quad (7)$$

The expression $r_{w,t1}$ corresponds to the rank of word w in the base corpus $t1$ whereas $r_{w,t2}$ is the rank of the same word w in the comparison corpus $t2$. The RRD therefore accounts not only for the rank differential but also for the frequency of the respective word in the base corpus. Consequently, rank differences for common words are weighted higher than those that are only used rarely. The least common words of a corpus are sparse words which have zero frequency in that respective corpus but are used in the comparison one and have the rank of $\underline{r_w}$ of the ordinal spectrum. Naturally, a word w with a positive RRD value corresponds to a word which is ranked higher in the base corpus and the magnitude of the metric determines the salience or "keyness" of the respective word.
As with other text mining procedures the RRD is calculated on supervised chat data to prevent any bias of the metric. For this we conduct the following modifications and filtration during a preprocessing stage. We remove any *punctuation* and *special characters* such as ("@" or "/"). Since capital letters are pretty common in the German language it is crucial to transform all letters to *lower case* to avoid a twofold listing of the identical word. Our vector of german specific *stopwords* which are filtered out includes all variations of conjunctions, definite and indefinite articles, and prepositions of location. Finally, we correct common *misspellings*, *typos* and merge *colloquial words* accordingly.[18] We report keywords in Tables D.3-D.5 whose original rank in the base corpus and rank differential satisfies $r_{w,t1} \leq 50$ and $RRD_{w,t1} \geq 3$ respectively.
The keyword comparison between both communication treatments in Table D.3 exhibits an almost identical number of total words ($W_{T20,T0}$) in both corpora. Key-

[17]The applied ranking method within the corpora naturally effects the ordinal spectrum $O = [\underline{r_w}, \overline{r_w}]$ and consequently the RRD. To conveniently compare ranking methods we provide a ranking of four items in which the first is ranked ahead while the last is ranked behind the second and third which are tied based on the ranking criteria. The standard competition ranking ("1224") and its modified version ("1334") are less condensing on O than the dense ranking ("1223") but the sum of assigned ranks varies with the number of ties. Especially for corpora containing only a limited amount of total words, like experiment chat, the probability of words having the same (low) frequency is quite high and the condensing effect is quite prevalent. Dense ranking would therefore severely reduce the ordinal spectrum to the number of different word frequencies we observe and consequently reduce the magnitude of the RRD. Therefore, we use fractional ranking ("1 2.5 2.5 4") as it is not only the least condensing method with respect to O but has also the property that the sum of all ranks is the same as in ordinal ranking ("1234") and independent of the number of ties which is needed for statistical tests.

[18]Colloquial speech that is transformed mostly contains all variations of negations ("nope", "nah") , affirmations ("yep", "yup" "yessir") and interjections of laughing and giggling ("haha", "tee-hee").

words used under switching costs contain statements of affirmation like "sure" or "absolutely" and words corresponding to the experimental environment as "market", "bet" or "say". The same is true for keywords used in T0 as we find affirmations "perfect" or "deal" and words that are used to communicate strategies like "per" and "time" as in the expression "each time". Further, the phrase of "1800" is also salient and corresponds to a firm's period profit if the market is repeatedly split at p^{max}. This could indicate that subjects use explicit calculations and profit targets to communicate a strategy and compare between them.[19] However, we consider the keywords of both corpora as somewhat neutral in a sense that it is difficult to deduct any indication from them on observed outcomes that are not significantly different anyhow.

By contrast, market outcomes, namely market state proportions as well as the price level, do differ between the first supergame and the latter two in both treatments. Table D.4 and D.5 display the keywords of the within treatment comparisons of supergames. What has already been indicated by the lower amount of *messages* sent in the respective first supergames translates also into total words used. Subjects do not only interact less prior to their first pricing decision but also use far fewer words on average compared to subsequent communication. To be precise, the amount of words increases by $28,37\%$ in T20 and $38,86\%$ in T0 on average.

For keywords in T20 we find again somewhat neutral words such as "product", "costs" in SG_1 or affirmations , "super", in $SG_{2,3}$ which where prevalent in the previous treatment comparison. However, the most salient keywords in the first supergame are either subjunctive, "were" or "(we) might", or noncommittal like "attempt", "suggest" or "(I) believe". Whereas in the subsequent supergames more binding words like "(we) both" and "always" are more salient. Apparently, communicated content in SG_1 is less definite and may indicate that subjects could be more uncertain about pricing decisions and the desirability of certain market outcomes due to somewhat vague communication.

We observe the same increased keyness for subjunctive expressions and noncommittal language in the supergame comparison of T0. Again words like "would", "suggest", "test" and "idea" can be found at the top of the RRD ranking indicating that the lack of definite language is not treatment specific. It is rather driven by subjects' inexperience of what specifically needs to be communicated to create an environment of stable collusion. However, subjects seem to gain that experience

[19]Interestingly, the word "switching costs" is more salient in N0 in which they are zero. However, this is due to one market in which subjects talk about the framing of the respective treatment and consequently use the specific word more frequently rather than the word being used in communication on pricing strategies.

after the first supergame. Keywords are then again "per", "always" and "1800" characterizing a more profound payoff evaluation but also "collusion" and "if" indicate more contingent price strategies. This is in line with findings of Cooper and Kühn (2014) who find that especially contingent messages including a punishment facilitate collusion.[20]

Hence, the salient noncommittal language together with fewer interactions in the respective first supergames provide an intuition on why market outcomes are less collusive. It seems that subjects need to learn how to use communication effectively in order to establish stable collusion.

6 Conclusion

Consumer switching costs impose a challenge for antitrust authorities in assessing firms' market power or cartel detection. Screening methods mostly focus on mean prices or the variance of the observed pricing distribution (Abrantes-Metz *et al.*, 2006). However, it is increasingly difficult to infer from these two moments to the competitiveness of the market if consumers face costs of switching their supplier. This is especially true if firms can distinguish locked-in from not locked-in consumers and will price according to an "invest-and-harvest" pattern in equilibrium (Klemperer, 1995). A screen would then perceive prices to consumers who haven not bought yet as potentially predatory and vis-à-vis locked-in consumers as collusive (Che *et al.*, 2007).

While finite time horizon models provide ambiguous results on switching costs' effect on the overall competitiveness, infinite frameworks established a somewhat conventional wisdom of a negative competitive effect. However, recent findings challenge this view (Dubé *et al.*, 2009).

This study sheds light on the competitive effects of firms' invest-and-harvest motive induced by switching costs and the scope for collusion on those markets that exhibit finitely participating, identifiable consumers. I investigate these issues by studying Bertrand duopolies in a laboratory environment which is seen as favorable for collusive behavior (Dufwenberg and Gneezy, 2000; Davies *et al.*, 2011).

The experimental data shows that firms price indeed lower and invest in a high market share early if consumer switching costs are present. However, price levels towards locked-in consumers do not differ to those of an otherwise identical market. Here, firms manage to establish a tacit collusive environment which they fail

[20]Bochet and Putterman (2009) also find that communicated content affect's subjects' real play and that especially the threat of punishment as a contingency facilitates efficiency.

to do if switching costs are present. Hence, the duopolistic environment is seemingly more competitive, firms' ability to collude tacitly is limited and, as a result, their supra-competitive profits plummet. This is especially present for firms who initially serve all consumers and possess a large customer base. The price distribution of these firms is centered around the equilibrium "harvesting" level and also exhibits a lower variance.

The results raise in fact some doubts about the predominant view that markets are less competitive under switching costs. A less tacit collusive price level may on the one hand limit the potential for consumer harm, but it also makes the option to collude explicitly on the other hand look more alluring. Explicit communication is indeed an effective coordination device on pareto-superior outcomes and is able to negate competitive effects induced by switching costs. These increased profit gains from communication are mainly driven by the intense competition for new consumers prior to lock-in if firms do not communicate. This stresses the importance of a state dependent approach for competition policy. Especially soft "investment" stages could be an indicator for collusive activities and a good starting point for cartel screening. However, the choice of cartel screen should also consider higher order distributional effects due to switching costs in order to avoid false positives.

Appendix A: Profit function

We define a firm i's profit in $k = 1, 2$ as

$$\pi_1^i = \begin{cases} (p_1^i - c^i)\, m & \text{if } p_1^i < p_1^j, \\ \frac{(p_1^i - c^i) m}{2} & \text{if } p_1^i = p_1^j, \\ 0 & \text{if } p_1^i > p_1^j. \end{cases}; \quad \pi_2^i = \begin{cases} (p_2^i - c^i)\, m & \text{if } p_1^i < p_1^j \wedge p_2^i < p_2^j + S, \\ \frac{(p_2^i - c^i) m}{2} & \text{if } p_1^i < p_1^j \wedge p_2^i = p_2^j + S, \\ 0 & \text{if } p_1^i < p_1^j \wedge p_2^i > p_2^j + S, \\ (p_2^i - c^i)\, m & \text{if } p_1^i = p_1^j \wedge p_2^i < p_2^j - S, \\ \frac{(p_2^i - c^i) 3m}{4} & \text{if } p_1^i = p_1^j \wedge p_2^i = p_2^j - S, \\ \frac{(p_2^i - c^i) m}{2} & \text{if } p_1^i = p_1^j \wedge p_2^j - S < p_2^i < p_2^j + S, \\ \frac{(p_2^i - c^i) m}{4} & \text{if } p_1^i = p_1^j \wedge p_2^i = p_2^j + S, \\ 0 & \text{if } p_1^i = p_1^j \wedge p_2^i > p_2^j + S, \\ (p_2^i - c^i)\, m & \text{if } p_1^i > p_1^j \wedge p_2^i < p_2^j - S, \\ \frac{(p_2^i - c^i) m}{2} & \text{if } p_1^i > p_1^j \wedge p_2^i = p_2^j - S, \\ 0 & \text{if } p_1^i > p_1^j \wedge p_2^i > p_2^j - S. \end{cases}$$

while corresponding profits of the rival j are derived analogously.

Appendix B: Proofs

Proof of Proposition 1

Proof. Intuitively, a firm i who served the entire market demand in $k = 1$ will set a price of $p_2^i = p_2^j + S - \gamma$ that maximally exploits its own customer base while securing not to lose any market share over to its rival as long as $p_2^j \geq c - S + \gamma$ with $\gamma \to 0$. If a rival prices below this threshold a firm i will rather serve no consumers since maintaining some market share would result in negative profits. Hence, there exist multiple equilibria in pure strategies that imply prices of

$$p_2^i = p_2^j + S \in [c, c + S] \quad ; \quad p_2^j \in [c - S, c]$$

in which the monopolist realizes non-negative payoffs and the outsider zero profits. However, weak dominance or the trembling-hand equilibrium refinement produces the known price equilibrium of Klemperer (1987b, Section 2) and Farrell and Klemperer (2007, Section 2.3.1)

$$p_2^{i^{MI}} = p_2^j + S = c + S; \quad p_2^{j^{MI}} = c\,. \tag{B.8}$$

This completes the proof. $\square$

Proof of Proposition 2

Proof. Given a firm i's installed customer base in a split subgame, its options are to optimally "harvest" existing customers with $p_2^i = p_2^j + S - \gamma$, win over half of the rival's customers with $p_2^i = p_2^j - S$ or monopolize the entire market at $p_2^i = p_2^j - S - \gamma$ for $\gamma \to 0$. However, profits in the states in which a firm i serves $\frac{1}{4}$ ($\pi_2^{i^{S,\frac{1}{4}}}$) or $\frac{3}{4}$ of market demand ($\pi_2^{i^{S,\frac{3}{4}}}$) can be characterized as irrelevant alternatives in terms of equilibria finding. Losing all prior market share due to overpricing its rival serves as an ever-present critical zero profit benchmark for a firm i.
Figure B.1 displays firm i's profits in a split subgame as a function of rival j's price ($\pi_2^i(p_2^j)$). Intercepts of the profit functions determine the relevant cut-offs for the characterization of firm i's best response.
A firm i will find it profitable to undercut any rival's price above $p_2^{j'}$ which satisfies

$$\pi_2^{i^{S,MI}} \geq \pi_2^{i^{S,S}} \;\Leftrightarrow\; (p_2^j - S - \gamma - c^i)m \geq (p_2^j + S - \gamma - c^i)\frac{m}{2}$$

and can be solved to be $p_2^{j'} = 3S + c^i + \gamma$. However, for $p_2^{j'}$ to be the relevant cut-off price it is required that $p_2^{j'} < p^{max} - S + \gamma$ such that a firm i can alternatively "harvest" its existing consumers with a mark-up of S while not exceeding the reservation price. Given **Assumption 1** this condition is however violated and firm i will set a price of $p_2^i = p^{max}$ in that case. This, consequently, reduces the attractiveness of "harvesting" and shifts the rival's price for which undercutting is profitable ($p_2^{j''}$) downwards. It is then defined as a solution to

$$\pi_2^{i^{S,MI}} \geq \pi_2^{i^{S,S\ max}} \;\Leftrightarrow\; (p_2^j - S - \gamma - c)m \geq (p^{max} - c)\frac{m}{2}$$

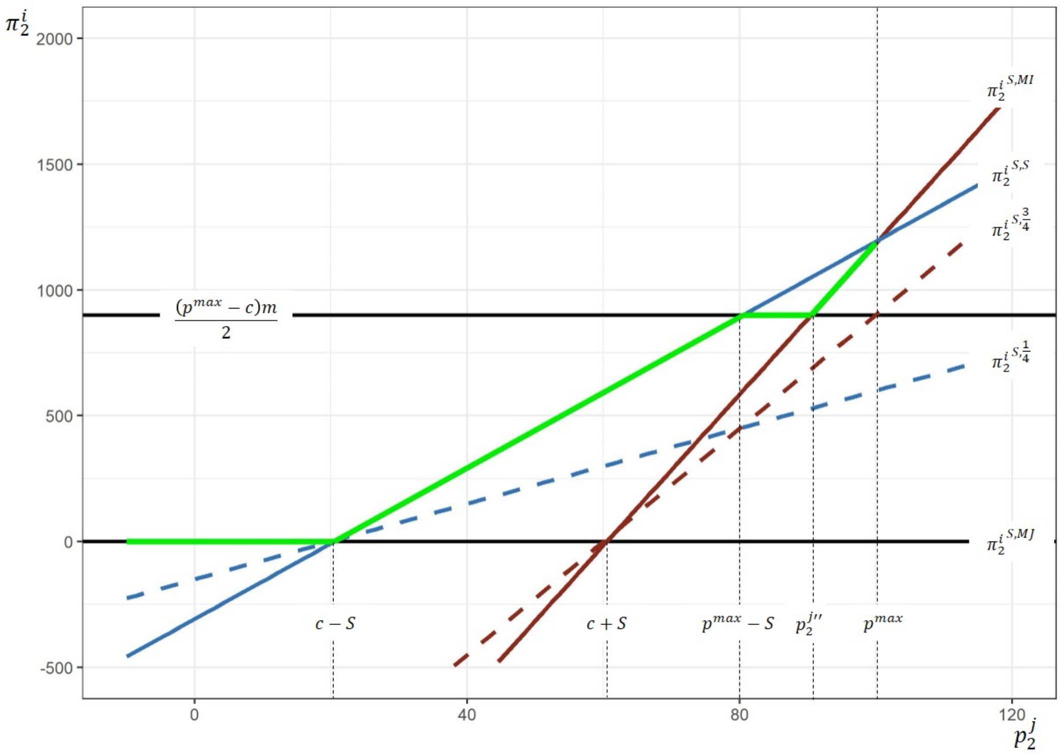
with $\pi_2^{i^{S,S\ max}}$ as the maximum profit a firm i can realize in $k = 2$ if the market is split. The solution to this inequality is $p_2^j \geq \frac{p^{max}+2S+c+2\gamma}{2} = p_2^{j''}$ and $[p_2^{j''}, p^{max}]$ defines rival's prices for which firm i finds it profitable to undercut.[21] Hence, for $\gamma \to 0$ a firm i will find it optimal to undercut rival's prices of

$$\frac{p^{max} + 2S + c}{2} \leq p_2^j \leq p^{max}.$$

[21] The condition of $S \leq \frac{p^{max}-c}{2}$ in **Assumption 1** secures that there is at least one price for which it is profitable to price aggressively and that $[p_2^{j''}, p^{max}]$ is a non-empty set.

The uniqueness of derived intercepts and cut-offs is secured by $\frac{\partial \pi_2^{i^{S,MI}}}{\partial p_2^j}, \frac{\partial \pi_2^{i^{S,\frac{3}{4}}}}{\partial p_2^j}, \frac{\partial \pi_2^{i^{S,S}}}{\partial p_2^j}, \frac{\partial \pi_2^{i^{S,\frac{1}{4}}}}{\partial p_2^j} > 0$.

Figure B.1: Firm i's profits and best responses in a split subgame



Notes: The displayed profit lines incorporate the experiment parameter values of $S = 20,\ c = 40,\ m = 30,\ p^{max} = 100$. Intercepts are provided for $\gamma \to 0$. A firm i's best response profits are colored in green.

Following this, one can state firm i's best response function as follows.

$$BR^{i^S}(p_2^j) = \begin{cases} p_2^j - S & \text{if } \frac{p^{max}+2S+c}{2} \leq p_2^j \leq p^{max}, \\ p^{max} & \text{if } p^{max} - S < p_2^j < \frac{p^{max}+2S+c}{2}, \\ p_2^j + S & \text{if } c - S \leq p_2^j \leq p^{max} - S, \\ p_2^i \in [c, p^{max}] & \text{if } p_2^j < c - S. \end{cases} \tag{B.9}$$

Applying the strict dominance criterion, we can derive two disjoint sets of non-dominated prices a firm i chooses with different intention. First, the range of "aggressive" prices $\mathbf{A} = \left[\underline{\alpha}, \bar{\alpha}\right]$ defined as

$$\mathbf{A} = \left[\frac{p^{max} + 2S + c}{2} - S - \gamma, p^{max} - S - \gamma\right]$$

a firm i would set in order to win over market share. Second, the set of "harvesting" prices $\mathbf{H} = \left[\underline{\epsilon}, \bar{\epsilon}\right]$ is then given as

$$\mathbf{H} = \left[\frac{p^{max} + 2S + c}{2} - \gamma, p^{max}\right] .$$

The latter one includes mainly the best responses on rival's aggressive prices. Please note that a price of $\bar{\epsilon} = p^{max}$ is firm i's best response on a rival's harvesting price that is just not profitable to undercut ($p_2^j = \underline{\epsilon}$). For every rival's harvesting price, except for $\underline{\epsilon}$, there exists a price for firm i to optimally undercut its rival. Thus, for $\gamma \to 0$ the interval length of $\mathbf{A}$ corresponds to the length of $\mathbf{H}$. Equation (B.10) then defines a firm i's best response after the iterated elimination of strictly dominated prices $BR^{i^{S*}}(p_2^j)$ and consequently constitutes firm i's set of rationalisable price strategies in a split subgame.

$$BR^{i^{S*}}(p_2^j) = \begin{cases} \mathbf{A} & \text{if } p_2^j \in \left]\underline{\epsilon}\,;\bar{\epsilon}\right], \\ \left[\underline{\epsilon}\,;\bar{\epsilon}\right[& \text{if } p_2^j \in \mathbf{A}, \\ \bar{\epsilon} = p^{max} & \text{if } p_2^j = \underline{\epsilon}. \end{cases} \tag{B.10}$$

The price spectrum of aggressive and harvesting prices does not exhibit any states of mutual best responses in pure pricing strategies. Hence, a firm i randomizes among the two disjoint sets of rationalisable strategies $p_2^i \in \mathbf{A}\dot{\cup}\mathbf{H}$ which constitutes an equilibrium in mixed strategies we define as $\mathit{\Gamma}$. Since $p_2^i = \underline{\epsilon}$ is not profitable to undercut, a firm i will always retain it's market share and will realize the same profit, even if the rival optimally responds with $p_2^j = \bar{\epsilon}$. As a consequence, it must retain the same expected profit as well in the mixed strategy equilibrium such that $E[\pi_2^i(\mathit{\Gamma})] = \pi_2^i(p_2^i = \underline{\epsilon})$ which converges to

$$\pi_2^{i^S} = \left(\frac{p^{max} + 2S + c}{2} - c\right)\frac{m}{2} = \left(\underline{\epsilon} - c\right)\frac{m}{2} \tag{B.11}$$

for $\gamma \to 0$. This completes the proof. □

Proof of Proposition 3.

Proof. Firms are anticipating market outcomes of $k = 2$ competition and maximize combined profits from both market stages in $k = 1$. We define $\Pi^{i^{MI}} = \pi_1^{i^{MI}} + \pi_2^{i^{MI}}$ as firm i's total profit if it monopolizes the market in the first period. Total profits of $\Pi^{i^S}; \Pi^{i^{MJ}}$ are defined analogously. It is obvious that a firm wants to avoid overpricing its competitor if possible in $k = 1$, since this implies zero profits in either market stage. However, this case is highly relevant as it always secures a non-negative payoff and serves as a minimum profit benchmark. The intercepts of total profits given rival's prices constitute the proposition. A firm i's total profits are defined as

$$\Pi^{i^{MI}} = \pi_1^{i^{MI}} + \pi_2^{i^{MI}} = \left(\left(p_1^j - \gamma\right) - c\right) m + S \cdot m$$

$$\Pi^{i^S} = \pi_1^{i^S} + \pi_2^{i^S} = \left(p_1^j - c\right) \frac{m}{2} + \left(\underline{\epsilon} - c\right) \frac{m}{2}$$

$$\Pi^{i^{MJ}} = \pi_1^{i^{MJ}} + \pi_2^{i^{MJ}} = 0 + 0\,.$$

The intercepts of *(i)* $\Pi^{i^S}(p_1^j) \geq \Pi^{i^{MJ}}(p_1^j)$, *(ii)* $\Pi^{i^{MI}}(p_1^j) \geq \Pi^{i^{MJ}}(p_1^j)$ and *(iii)* $\Pi^{i^{MI}}(p_1^j) \geq \Pi^{i^S}(p_1^j)$ then determine, for which rival prices respective profits are greater than zero (rival monopolization) or it is profitable to monopolize rather than splitting the market early. The solutions to the above inequalities for $\gamma \to 0$ are as follows.

(i)

$$p_1^j \geq 2c - \underline{\epsilon}$$

(ii)

$$p_1^j \geq c - S$$

(iii)

$$p_1^j \geq \underline{\epsilon} - 2S$$

One can show that the derived thresholds can be ordered such as $(i) < (ii) < (iii)$ given **Assumption 1**. Since $\Pi^{i^{MI}}$ and Π^{i^S} are both monotonically increasing functions in p_1^j the derived intercepts are unique. Hence for rival prices of

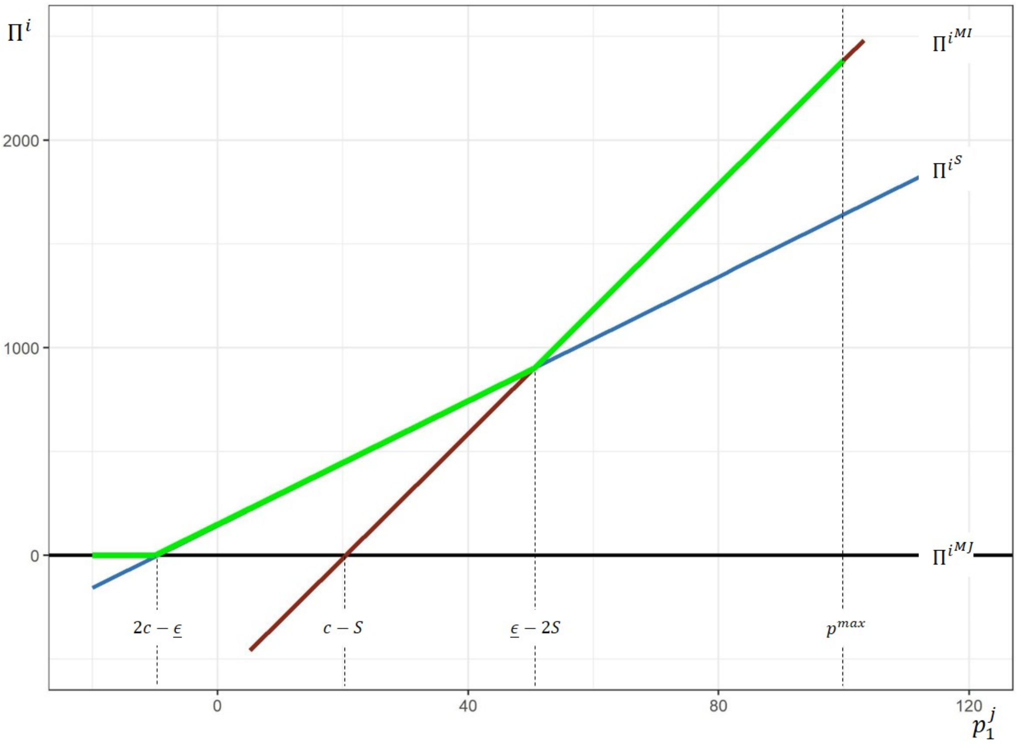
$$p_1^j \in \left[2c - \underline{\epsilon}\,;\ \underline{\epsilon} - 2S\right] \tag{B.12}$$

total profits of sharing the market in $k = 1$ exceed those from own monopolization and are non-negative. Consequently, if the rival chooses a price as part of the above interval a firm i rather wants to price identical $p_1^i = p_1^j$ and share market demand. This implies the existence of multiple subgame perfect Nash-equilibria in pure price strategies. In equilibrium total profits are of the interval

$$\Pi^{i^*} \in \left[0, \left(2\underline{\epsilon} - 2c - 2S\right)\right) \frac{m}{2}\right] \ . \tag{B.13}$$

Figure B.2 illustrates firms' total profits of the reduced game and relevant intercepts. This completes the proof. □

Figure B.2: Profits of the reduced switching cost game



Notes: Firms' total profits of the reduced form game in case of market sharing (Π^{i^S}), own and rival's monopolization ($\Pi^{i^{MI}}$, $\Pi^{i^{MJ}}$) as a function of rival's price (p_1^j). Firm i's best response profits are highlighted in green.

The symmetric distribution of market shares in a split subgame severely decreases price competition compared to a monopolization subgame. Although monopoly profits always exceed those from market sharing in $k = 1$, they will not necessarily make up for reduced profits in $k = 2$. Only for rival's prices that lie above the interval of (B.12) monopolization is optimal. Hence, for prices within the interval firms want to coordinate and price identically rather than aggressively to take advantage of relaxed subsequent price competition in a split subgame. If however the rival prices such as $p_1^j < 2c - \underline{\epsilon}$ even splitting marked demand in $k = 1$ is not profitable. A firm i then optimally overprices and serves no consumers since price discounts in $k = 1$ could not be recouped by profits in $k = 2$.

Appendix C: Dynamic competition

For the repeated game we assume that collusive firms coordinate on prices that maximize joint cartel profits irrespective of the existence of switching costs. Hence, firms charge the reservation price in $k = 1, 2$ and share market demand twice. An explicitly collusive firm i then sets prices of $p_1^{i^C}, p_2^{i^C} = p^{max}$ under switching costs and $p_B^{i^C} = p^{max}$ under the Bertrand benchmark.
Given that firms employ a Nash-reversion grim trigger strategy as a punishment, cartel sustainability and equilibria of the repeated game differ in two dimensions. First, the static switching cost game exhibits multiple Nash-equilibria in pure strategies. Therefore, a firm i has the opportunity to employ either of these as a competitive threat as part of the punishment scheme. Therefore, firms can either punish *harshly* in setting the lowest equilibrium price of $p_1^i = 2c - \underline{\epsilon}$ or more *smoothly* in granting positive competitive profits. Second, the two market stages within a playing period enable firms to deviate either in $k = 1$ or $k = 2$. Given **Assumption 1**, a deviation in $k = 1$ is always preferable to a deviation in $k = 2$ if switching costs are present. In treatment T0 firms rather deviate in the second market stage of Bertrand competition. Table C.1 displays the minimum discount factors for every deviation-punishment pair which secure that all prices up to p^{max} can be sustained in a symmetric collusive equilibrium.
If switching a supplier is costly, a firm who wants to deviate will do so optimally in $k = 1$. Then it depends on the punishment intensity whether switching costs facilitate cartel sustainability or not. If firms employ indeed a harsh punishment scheme that implies competitive profits of zero, collusion is easier to sustain under switching costs. The contrary applies if firms in fact punish rather smoothly. For the specific experiment parameters the highest discount factor required for collusive equilibria is that of an early deviation under a smooth punishment regime of $\delta_{SC}^{i^{S,E}} = \frac{2}{5}$. If subjects perceive the game's continuation probability of $\frac{7}{8}$ in fact as a discount factor, then coordination on every price of the spectrum is an equilibrium outcome of the repeated game. Bó (2005) finds for repeated prisoner's dilemma games that the continuation probability has indeed an effect on subjects' play.

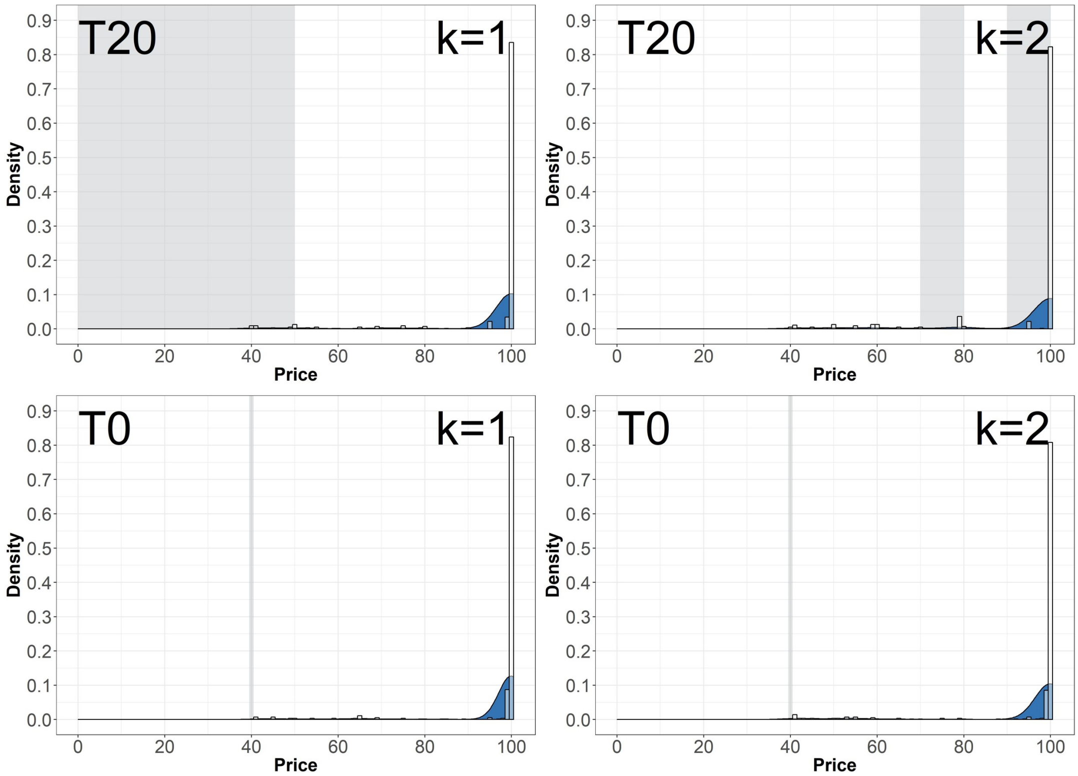
Table C.1: Minimum discount factors by punishment intensity and deviation timing

	Early deviation	Late deviation
Bertrand competition	$\frac{1}{1-\delta}\Pi^{i^{2C}} \geq (p^{max} - c)m$ $\delta_B^{i^E} \geq 0$	$\frac{1}{1-\delta}\Pi^{i^{2C}} \geq \Pi^{i^C} + (p^{max} - c)m$ $\delta_B^{i^L} \geq \frac{1}{3}$
Switching costs		
Harsh punishment	$\frac{1}{1-\delta}\Pi^{i^{2C}} \geq [(p^{max} - c)m + S \cdot m]$	$\frac{1}{1-\delta}\Pi^{i^{2C}} \geq [\Pi^{i^C} + (p^{max} - S - c)m]$
	$\delta_{SC}^{i^{H,E}} \geq 1 - \frac{p^{max}-c}{p^{max}-c+S}$	$\delta_{SC}^{i^{H,L}} \geq 1 - \frac{p^{max}-c}{\frac{3}{2}(p^{max}-c)-S}$
	$0, \delta_{SC}^{i^{H,L}} < \delta_{SC}^{i^{H,E}} < \frac{1}{3}, \delta_{SC}^{i^{S,E}}$	$0 < \delta_{SC}^{i^{H,L}} < \frac{1}{3}, \delta_{SC}^{i^{H,E}}, \delta_{SC}^{i^{S,L}}$
Smooth punishment	$\frac{1}{1-\delta}\Pi^{i^{2C}} \geq [(p^{max} - c)m + S \cdot m]$ $+\frac{\delta}{1-\delta}\left[\left(2\underline{\epsilon} - 2c - 2S\right)\frac{m}{2}\right]$	$\frac{1}{1-\delta}\Pi^{i^{2C}} \geq [\Pi^{i^C} + (p^{max} - S - c)m]$ $+\frac{\delta}{1-\delta}\left[\left(2\underline{\epsilon} - 2c - 2S\right)\frac{m}{2}\right]$
	$\delta_{SC}^{i^{S,E}} \geq \frac{S}{\left(\frac{p^{max}-c}{2}+S\right)}$	$\delta_{SC}^{i^{S,L}} \geq \frac{\frac{1}{2}(p^{max}-c)-S}{(p^{max}-c-S)}$
	$\frac{1}{3}, \delta_{SC}^{i^{H,E}}, \delta_{SC}^{i^{S,L}} < \delta_{SC}^{i^{S,E}} < \frac{1}{2}$	$0, \delta_{SC}^{i^{H,L}} < \delta_{SC}^{i^{S,L}} < \frac{1}{3}, \delta_{SC}^{i^{S,E}}$

Notes: $\Pi^{i^C} = (p^{max} - c)\frac{m}{2}$ is defined as the cartel profit of a single market stage and is identical for competition with and without switching costs. $\Pi^{i^{2C}} = 2 \cdot \Pi^{i^C}$ is then the cartel profit of two market stages and an entire playing period. Under "harsh punishment" the smallest competitive equilibrium profit of zero is used as a punishment threat, whereas "smooth punishment" corresponds to the highest competitive equilibrium profit.

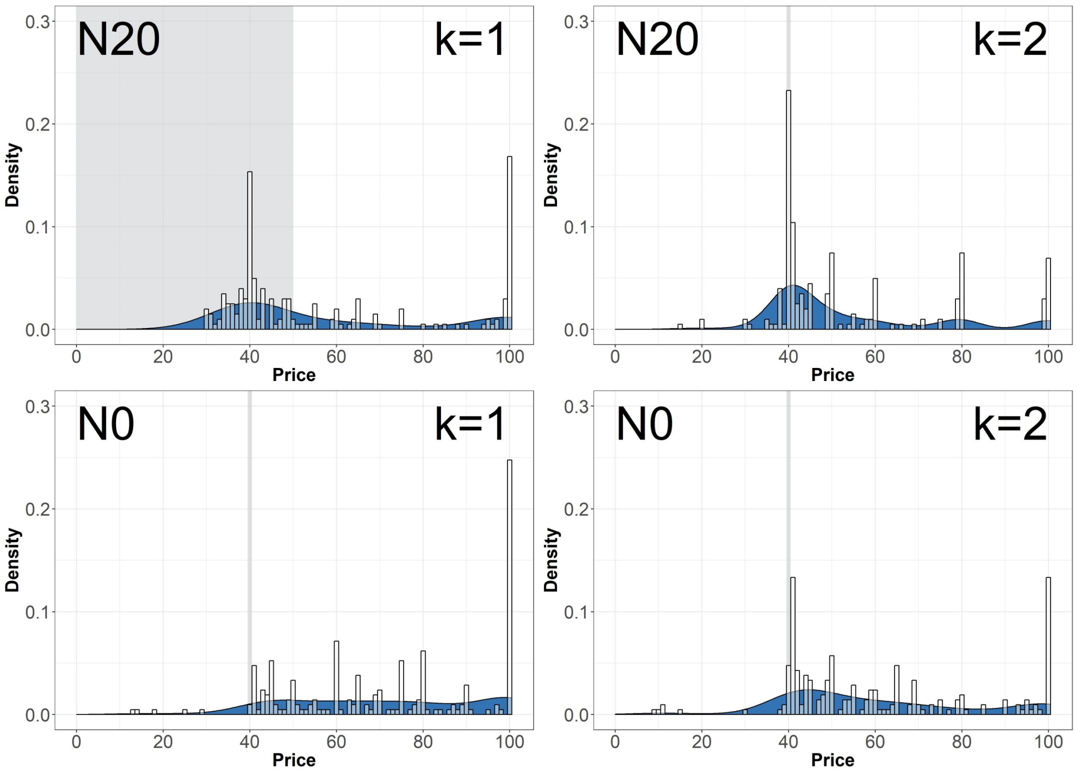
Appendix D: Figures & tables

Figure D.1: Price distributions of communication treatments across subgames



Notes: Displayed distributions incorporate posted prices in all supergames and subgames. Grey highlighted areas correspond to prices of the subgame perfect Nash-equilibrium of the static game. Kernel densities are estimated via the Gaussian Kernel function and bandwidth is one standard deviation of the kernel.

Figure D.2: Outsiders' price distributions of non-communication treatments



Notes: Displayed distributions incorporate posted prices in all supergames of firms who overpriced in $k = 1$ and consequently served no demand initially. Grey highlighted areas correspond to prices of the subgame perfect Nash-equilibrium of the static game. Kernel densities are estimated via the Gaussian Kernel function and bandwidth is one standard deviation of the kernel.

Table D.1: Difference-in-difference estimation

	Dependent variable: *Mean market period profit*		
	SG_1	SG_2	SG_3
Communication dummy	1,200.42***	1,048.44***	795.75***
	(87.48)	(52.46)	(69.64)
SCost dummy	35.31	−266.30***	−577.75***
	(87.48)	(52.46)	(69.64)
Comm-SCost-Interaction	−344.06***	337.86***	561.25***
	(123.71)	(74.18)	(98.48)
Constant	296.67***	654.89***	998.25***
	(61.86)	(37.09)	(49.24)
Observations	288	576	240
Adj. R^2	0.499	0.657	0.695

Notes: Estimated OLS regression coefficients with robust standard errors in parenthesis. The dependent variable is the mean profit of a market in a playing period. *Communication dummy* is a dummy, which takes the value 1 for observations from communication treatments T20 & T0. *SCost dummy* is a dummy, which takes value 1 if observations are from treatments with Switching Costs N20 & T20. *Comm-SCost-Interaction* is an interaction of the previous two dummies. Significance levels of the coefficients are indicated according to *p<0.1; **p<0.05; ***p<0.01.

Table D.2: Firms' mean profits by period and market stage

Profits (Taler /Period) (Taler /Market phase)	Aggregate		Monopolist		Outsider		Splitter	
N20	**380.8**		**714.7**		**3.71**		**439.7**	
	64.08	316.68	161.44	553.22	0	3.71	18.65	421.01
N0	**636.1**		**743.8**		**180.8**		**1189.1**	
	332.9	303.2	496.7	247.1	0	180.8	601.8	587.3
T20	**1622.4**		**1266.7**		**292.7**		**1786.6**	
	819.6	802.8	836.7	430.0	0	292.7	897.8	888.8
T0	**1669.2**		**1608.2**		**1053.0**		**1795.6**	
	842.4	826.8	1376.4	231.8	0	1053.0	899.9	895.7

Notes: Bold values display mean profits of a total playing period, plain values refer to mean profits in the respective market stages.

Table D.3: Keywords in whole treatments T20 and T0

$T20$			$W_{T20} = 1476$	$T0$			$W_{T0} = 1458$
Word	Freq.	Rank	RRD to $T0$	Word	Freq.	Rank	RRD to $T20$
many	8	30.5	16.62	deal	10	26.5	19.57
market	8	30.5	16.62	switching costs	6	44	11.39
absolutely	6	42	11.80	per	17	11	8.45
bet	8	30.5	8.93	(each) time	13	17.5	8.40
say	6	42	6.21	I	7	37.5	7.56
sure	11	21.5	4.05	perfect	12	20	7.23
go	9	24.5	3.43	1800	10	26.5	5.21
have	7	36.5	3.21	shall	12	20	4.20
give	12	19	3.16				

Notes: Words are ordered according to the RRD towards the respective treatment which is calculated according to (7). Only words whose original rank in the base corpus ($t1$) and rank differential satisfies $r_{w,t1} \leq 50$ and $RRD_{w,t1} \geq 3$ are displayed. Punctuation, articles, conjunctions and prepositions of location are ommited. Words are translated from German.

Table D.4: Keywords in the first supergame and the latter two of T20

SG_1			$W_1 = 393$	$SG_{2,3}$			$W_{2,3} = 1083$
Word	Freq.	Rank	RRD to SG_23	Word	Freq.	Rank	RRD to SG_1
attempt	3	26.5	18.30	many	8	21	18.76
(I) see	4	19.5	12.69	to me	8	21	18.76
know	2	45	10.37	none	8	21	18.76
were	2	45	10.37	has	8	21	18.76
suggest	2	45	10.37	absolutely	6	29	13.31
our	2	45	10.37	(we) both	6	29	13.31
get	2	45	10.37	super	13	12	8.83
half	2	45	10.37	total	8	21	4.62
(I) believe	2	45	10.37	always	39	3	4.50
900	4	19.5	5.59	have	6	29	3.07
choose	2	45	4.93				
already	2	45	4.93				
product	2	45	4.93				
costs	2	45	4.93				
(we) might	2	45	4.93				
you're welcome	2	45	4.93				
(I) think	2	45	4.93				
agree	3	26.5	3.85				

Notes: Words are ordered according to the RRD towards the respective supergame(s) which is calculated according to (7). Only words whose original rank in the base corpus ($t1$) and rank differential satisfies $r_{w,t1} \leq 50$ and $RRD_{w,t1} \geq 3$ are displayed. Punctuation, articles, conjunctions and prepositions of location are ommited. Words are translated from German.

Table D.5: Keywords in the first supergame and the latter two of T0

SG_1			$W_1 = 386$	$SG_{2,3}$			$W_{2,3} = 1072$
Word	Freq.	Rank	RRD to $SG_2 3$	Word	Freq.	Rank	RRD to SG_1
would	3	28	17.21	has	13	11.5	34.78
that	4	18.5	13.00	have	7	27.5	13.96
price	7	10	10.70	more	6	31	12.27
suggest	2	49.5	9.30	exactly	6	31	12.27
test	2	49.5	9.30	per	16	9	12.11
idea	2	49.5	9.30	collusion	5	39	9.55
had	2	49.5	9.30	(it) worked	5	39	9.55
alternate	2	49.5	9.30	go	5	39	9.55
second	3	28	8.25	first	5	39	9.55
most	3	28	8.25	(I) am	5	39	9.55
switching costs	4	18.5	5.32	many	10	17	5.94
none	5	14	4.29	1800	9	20.5	4.76
probably	2	49.5	4.23	(we) both	8	24.5	3.82
kidding	2	49.5	4.23	if	13	11.5	3.30
reverse	2	49.5	4.23	always	34	4.5	3.11
tip	2	49.5	4.23				
next	2	49.5	4.23				
sounds (good)	2	49.5	4.23				
highest	2	49.5	4.23				
equally	2	49.5	4.23				
sense	3	28	3.18				
thanks	3	28	3.18				

Notes: Words are ordered according to the RRD towards the respective supergame(s) which is calculated according to (7). Only words whose original rank in the base corpus ($t1$) and rank differential satisfies $r_{w,t1} \leq 50$ and $RRD_{w,t1} \geq 3$ are displayed. Punctuation, articles, conjunctions and prepositions of location are ommited. Words are translated from German.

Appendix E: Experimental Instructions

Instructions for T20 treatment (translations from German)

Welcome to the experiment. Please read the following instructions carefully. In this experiment you can earn money dependent on your decisions and that of others. Please remain quiet during the experiment and do not communicate with other participants. Raise your hand in case you have any questions.

In the experiment you represent a company which is in a market with another firm. Over the course of each **game** you are always in the market with the identical firm. Each **game** can consist of multiple **rounds**. After each **round** within a **game**, the **game** continues with a probability of $\frac{7}{8} = 87.5$**%**. The probability is constant and identical in each **round**. Whether the **game** continues is determined at the end of each **round** by drawing a random number between 0 and 1. The game continues as long as this random number is smaller than the value of 0.875.

Please note: Expected payoffs of the next **round** depend also on the continuation probability of 87.5%.

Prior to each **game** you are randomly matched to another participant to form a market. Before each **game** starts, you both are able to communicate with each other via chat for 2 minutes. The experiment ends after 3 **games** have been played.

In each **round** you represent a company that manufactures a product at costs of 40 ECU per unit! The market consist of 30 consumers who all want to buy one unit of the good at the cheapest price. Their maximum willingness to pay is 100 ECU and they will not buy a unit of the product at a price above that threshold. Each of the two companies in a market is able to serve all 30 consumers.

Each **round** consists of two stages. **Market stage 1** and **market stage 2**.

In **market stage 1** both firms decide on their selling prices from the continuous set of $[0, ..., 100]$ and the firm with the lowest price sells it's product at this price. In this case the other firm sells to no consumers. If both firms post simultaneously the lowest selling price, consumers' demand is equally split between both firms. Please see the following examples for clarification:

Example 1: Suppose firm 1 chooses a selling price of 85 and firm 2 a selling price of 75. Firm 2 therefore sets the lowest price and sells 30 units at price of 75. Considering the unit costs of 40 firm 2 earns 1050 ECU. Firm 1 sells to no consumers and earns 0 ECU. Calculation of firm 2's payoff: $(75-40) \cdot 30 = 1050$.

Example 2: Suppose firm 1 and firm 2 choose both a selling price of 70. Since they both charge the lowest price, consumers' demand is equally split up. Both firms sell 15 units at the chosen price of 70. Both firms earn, again considering unit costs, a payoff of 450 ECU. Calculation of firm 1's & 2's payoff: $(70-40) \cdot 15 = 450$.

At the end of **market stage 1** each firm is informed about chosen prices of both firms and its own payoffs. After this, **market stage 2** starts.

In **market stage 2** firms again choose their selling prices. However, consumers got used to the supplier's product which they bought previously. For the purchasing decision in market stage 2 they therefore tend to buy the product from their initial supplier at which they have already bought before in market stage 1. Consumers face switching costs of 20 ECU in case they switch to the product of the other firm. Hence, consumers only switch if the price of the other firm is attractive such that it compensates the consumers for the incurred switching costs. If consumers are indifferent between buying again at the same firm or switching to the other (selling prices plus switching costs are identical to consumers), demand of those indifferent consumers is equally split up between both firms. Please see the following examples for clarification:

Example 3a: Suppose all consumers bought the product of firm 1 in market stage 1. In market stage 2 firm 1 chooses a selling price of 75 and firm 2 of 60. For the consumers it is cheapest to buy again at firm 1 since they would face a selling price of 60 and switching costs of 20 in case they switch to firm 2. Firm 1 therefore sells 30 units at a price of 75 and earns, considering unit costs, a payoff of 1050 ECU. Calculation of consumers' purchasing decision:
$Price\ of firm\ 1 < Price\ of\ firm\ 2 + Switching\ costs\,; 75 < 60 + 20.$

Example 3b: Suppose all consumers bought the product of firm 1 in market stage 1. In market stage 2 firm 1 chooses a selling price of 75 and firm 2 of 50. For the consumers it is now cheapest to switch to the product of firm 2 despite the switching costs. Calculation of consumers' purchasing decision: $75 > 50 + 20$.

Example 3c: Suppose all consumers bought the product of firm 1 in market stage 1. In market stage 2 firm 1 chooses a selling price of 75 and firm 2 of 55. For the consumers both firms charge the cheapest price. In this case consumers are indifferent and their demand is split up equally. Calculation of consumers' purchasing decision: $75 = 55 + 20$. Payoff calculation: firm 1 $(75 - 40) \cdot 15 = 525$; firm 2 $(55 - 40) \cdot 15 = 225$.

Example 4: Suppose consumers' demand has been equally split in market stage 1 (see example 2). In market stage 2 firm 1 chooses a selling price of 75 and firm 2 of 60. For the customers of both firms it is cheapest to buy again at the same firm as in market stage 1. Calculation of consumers' purchasing decision: firm 1 customers stay because of $75 < 60+20$; firm 2 customers stay because of $75+20 > 60$.

At the end of market stage 2 each firm is informed about chosen prices of both firms and its own payoffs. In addition to this you have access to a profit calculator for your pricing decision.

You will earn money based on your cumulative earnings in the experiment at an exchange rate of:

$$1\ EUR = 3000\ ECU$$

Additionally you are endowed with an income of $4\ EUR$. In case you make a loss, this will be set off against your initial income. Before the experiment starts please answer the introductory questions which will be displayed on your screen in a moment. The correct answers will be given after this.

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