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Search Costs in Concentrated Markets - An Experimental Analysis

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Abstract

This paper experimentally studies the role of search cost in duopoly markets where sellers may be able to coordinate pricing decisions. We vary the level of search cost and whether sellers can communicate. While we find that consumers are more likely to invest in search when cost is reduced, we find that a reduction of search cost does not influence prices. This effect is not influenced by the availability of seller communication. Our results suggest that policy interventions that aim to increase the competitiveness of markets via reducing search cost may not be effective in concentrated markets.

JEL Classification: K23, L13, L51

Keywords: Search; Collusion; Regulation

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1 Introduction

In many markets consumers are only imperfectly informed about prices and face search cost to find the best deal. This is, in particular, true for many utilities such as energy or telecommunications. Another example are gasoline markets where, due to frequent price changes, consumers rarely know which firm offers the lowest price. A key characteristic of the above mentioned examples is that they are typically concentrated markets with only a few major firms dominating the market.

Policy makers are concerned about potential high prices in such markets, and there has been a recent interest in interventions to increase price transparency. For instance, the use of price comparison websites for utilities has been promoted in many countries. In gasoline markets, a number of countries (such as Australia, Canada, Germany or Austria) have backed interventions to reduce consumers' search cost. It is, however, a rather open question how effective such policies are.

In this paper, we present results of a laboratory experiment which helps answer this question. We consider a setting based on the search model by Stahl (1989) with two types of buyers. A share of buyers, called shoppers, is always informed about all sellers' prices while the remaining share, called non-shoppers, can only become informed at a cost. Search is sequential in the sense that the non-shoppers observe the price of one randomly drawn seller and then decide whether to invest in search. In a static framework, Stahl (1989) shows that sellers mix over prices and the price distribution is such that in equilibrium non-shoppers never search. Search cost, however, matter in the sense that the price distribution shifts downward as the search cost becomes smaller leading to lower average prices.

In our setting, we focus on concentrated markets with two sellers. We extend Stahl's model and consider a dynamic variant where the same two firms compete repeatedly over time. With an infinite time horizon cooperative equilibria, e.g. both sellers set the monopoly price, exist, if firms are sufficiently patient. Lowering search cost make such cooperative equilibria more likely as punishment profits (that is, equilibrium profits in the static equilibrium) decrease when search cost become smaller. Thus, while search cost for buyers may be beneficial for sellers if they compete, the opposite effect may occur if firms can coordinate pricing decisions.

We consider experimental markets with two sellers and two buyers, i.e. both were represented by participants in the lab. We vary two treatment variables, the level of search cost is either high or low and on the other hand pre-play communication between sellers is either possible or not. Sellers set their price, upon observing the price, buyers choose whether they invest in search and from which seller to purchase the product. Buyers were asked for their entire search strategy, i.e. they decided for every possible price whether they want to invest in costly search. The search strategy was applied according to the observed price. Sellers were allowed to communicate via unrestricted written messages, the conversation could not be followed by the buyers. In order to reflect a dynamic setup, market constellations were held constant throughout the experiment and we implemented a random stopping rule.

Our experimental findings suggest that interventions which aim at decreasing consumer search cost are not an effective tool to lower prices in concentrated markets. While buyers search more frequently with lower search cost, average prices do not vary with the level of the search cost. In contrast to predictions, we find that prices are more dispersed when search cost is low. Moreover, because lower search cost goes along with more frequent search, the consumer surplus is unaffected by changes in cost. Seller communication, on average, increases prices and reduces search incentives, however, lower search costs have no effect on prices and buyer surplus.

Our design allows us to shed light on buyers' search strategies. We find that, for any given price, a buyer is more likely to invest in search when search cost is low. More importantly, however, we also find that buyers are much less likely to search if sellers can communicate. This is consistent with the view that price coordination is higher with communication which reduces the incentives to search. Comparing the observed search strategy with the optimal one, we find that without communication, there is too much search at low prices, but too little search at high prices. This effect is more pronounced at lower search cost. In contrast, with communication there is always too much search.

A number of experimental studies investigate search markets. Closest to our paper is the study by Cason and Friedman (2003). Based on Burdett and Judd (1983) they investigate the impact of different shopper (each is matched with two sellers at the same time) and non-shopper (each is matched with one seller) ratios. In addition, they also vary whether buyers are computerized or active participants in the lab. Our contribution differs in several aspects from theirs. First, our experimental design allows us to observe the entire search strategy, i.e. we are able to identify why Cason and Friedman observe differences between computerized and participating buyers. Second, we focus on dynamic competition and potential collusion (with possible seller communication) which is not studied in their experiment.

Davis and Holt (1996) conducted an experiment on search markets which aims to test the validity of the Diamond paradox (Diamond, 1971). When all buyers have positive search cost, the prediction is monopoly pricing independent of the level of search cost. In contrast, Davis and Holt find a positive relationship between prices and the level of search cost. Abrams et al. (2000), also based on Burdett and Judd (1983), compare treatments where theory predicts either monopoly or marginal cost pricing. In contrast to the predictions they find that prices are biased towards the middle of these extremes. Cason and Datta (2006) report an experiment where sellers set prices and decide whether to advertise while buyer search is costly. They find that an increase in search cost raises equilibrium prices and increases sellers' advertising intensity.

Few studies consider collusion with search. To our knowledge, Orzen (2008) is one exception.[1] In this paper, buyers are simulated by a computer and consumer information, as measured by the share of informed buyers, is varied exogenously. In contrast, in our experiment buyers are participants in the lab and buyer information is an endogenous decision. Normann and Wenzel (2013) and Crosetto and Gaudeul (2016) also consider collusion in markets where consumers are not perfectly informed, but in their experiments it is sellers rather than buyers who can influence consumer information via obfuscation and confusion strategies.

The remainder of the paper is organized as follows. Section 2 outlines the theoretical background. Section 3 describes our experimental setup. In Sec-

[1] The paper uses a similar experimental setting as in Morgan et al. (2006a) which focuses on static competition.

tion 4 we present the experimental findings. Finally, Section 5 concludes.

2 A sequential search model

2.1 Static competition

This section presents a sequential search model along the lines of Stahl (1989). We consider a duopoly version where a unit mass of consumers each demands one unit of a homogenous product up to a reservation value of r.

There are two groups of consumers, shoppers and non-shoppers. The mass of shoppers (non-shoppers) is μ $(1-\mu)$. Sampling of the first product is costless for both groups, and each consumer receives price information by one randomly chosen firm (with equal probability). For sampling the second product and to learn its price, consumers have to incur a search cost. Shoppers have zero search cost and, hence, always sample both products while non-shoppers have to incur a positive search cost of $c > 0$. Non-shoppers will only invest into search if the benefit of searching (i.e., the possibility of finding a lower price) outweighs the search cost.

The equilibrium of the static game, where firms compete only once, is characterized as follows:[2]

Lemma 1. i) Firms price according to

$$F(p) = 1 - \frac{1-\mu}{2\mu}\left[\frac{\bar{p}}{p} - 1\right] \tag{1}$$

on $p \in [\underline{p}, \bar{p}]$, where

$$\bar{p} = \min\left\{r, \frac{c}{1 - \frac{1-\mu}{2\mu}\ln\left(\frac{1+\mu}{1-\mu}\right)}\right\} \tag{2}$$

[2]The derivation of the equilibrium follows the one in Stahl (1989) and is therefore omitted. The only difference is that Stahl assumes downward sloping demand while we consider unit demand.

$$\underline{p} = \frac{1-\mu}{1+\mu}\bar{p}. \tag{3}$$

Firms earn profits of $\Pi_c = \frac{1-\mu}{2}\bar{p}$.

ii) Non-shoppers employ a cut-off search strategy with cut-off price $\bar{p}$, but do not search in equilibrium.

The equilibrium structure is as follows. Equilibrium pricing is in mixed strategies due to the trade-off of charging a high price towards non-shoppers and competing for shoppers by offering a low price (Varian, 1980). In equilibrium, shoppers (with zero search cost) sample both firms, hence, buy from the firm that offers the lowest price. In contrast, non-shoppers (those consumers with a positive search cost c) employ a cut-off search strategy (with cut-off price $\bar{p}$), but in equilibrium they do not search and buy randomly from one of the firms. As a consequence, non-shoppers pay on average a higher price than shoppers.

It should be noted that the interval over which firms randomize prices depends on the level of the search cost. The upper bound is set such that non-shoppers only sample one firm (Stahl, 1989). The lower the search cost, the lower is the upper bound of the price distribution. If search cost is low, competition is high and the lower bound approaches marginal cost (here zero) for zero search cost. If, however, search cost is relatively high ($c \geq r\left[1 - \frac{1-\mu}{2\mu}\ln(\frac{1+\mu}{1-\mu})\right]$) the upper bound of the price distribution would be equal to reservation value of r and, hence, pricing would not depend on the search cost. In the following we will focus on cases where search cost matter, that is, $c < r\left[1 - \frac{1-\mu}{2\mu}\ln(\frac{1+\mu}{1-\mu})\right]$.

We are interested in studying the effects of a reduction in the search cost. A reduction of the search cost c shifts the price distribution $[\underline{p}, \bar{p}]$ downwards. Note also from Proposition 1 that equilibrium profits are proportional to the upper bound of the price distribution. As a reduction of the search cost shifts the upper bound downwards, profits are affected negatively. As demand is inelastic, consumer surplus is inversely related to industry profits so that with lower search cost consumer surplus increases.

This can also be seen by inspecting average market prices. The expected market price can be calculated as follows:

$$E(p) = \int_{\underline{p}}^{\bar{p}} p f(p) dp, \tag{4}$$

where $f(p)$ is the density function associated with the equilibrium distribution function $F(p)$. Simplification then yields:

$$E(p) = \frac{c \ln(\frac{1+\mu}{1-\mu})}{\frac{2\mu}{1-\mu} - \ln(\frac{1+\mu}{1-\mu})}. \tag{5}$$

It is straightforward to see that $\frac{\partial E(p)}{\partial c} > 0$. That is, a reduction in search cost c leads to a reduction of the average price in the market. We summarize the effects in the static game:

Proposition 1. In the static game, reducing search cost leads to lower expected market prices, reduced firm profits and higher consumer surplus.

2.2 Dynamic competition

We now study an infinitely repeated version of the static game presented in the preceding section. We focus on the case where firms may collude on the highest possible profits and analyze how a reduction in search cost influences firms' ability to collude.

The collusive price that maximizes joint industry profits is both firms choosing the price equal to consumers' reservation value, r. If both firms charge identical prices, non-shoppers have no incentive to incur costly search effort, no matter how small the search cost might be. Hence, non-shoppers buy randomly from the firm whose price they can observe. In contrast, shoppers who have no search cost still observe both prices and are indifferent between both firms' offers. Profits under this collusive strategy amount to:

$$\Pi_k = \frac{r}{2}. \tag{6}$$

A firm considering to deviate can only reach shoppers (zero search cost) as only this group compares the prices of the two firms. The optimal deviation is then to slightly undercut the collusive price as to capture all shoppers. Profits of the deviating firm are then

$$\Pi_d = \left[\frac{(1-\mu)}{2} + \mu\right] r = \frac{r(1+\mu)}{2}. \tag{7}$$

We consider trigger strategies. With this strategy, if all firms behave according to the collusive strategy, firms will continue to set the collusive price. However, as soon as any deviation occurs, collusion stops and firms revert to the static Nash equilibrium, earning profits of Π_c for the remaining periods. The critical discount factor, for collusion to be a subgame perfect equilibrium of the infinitely repeated game, is

$$\overline{\delta} = \frac{\Pi_d - \Pi_k}{\Pi_d - \Pi_c}, \tag{8}$$

which, applied to the above framework, can be expressed as

$$\overline{\delta} = \frac{r\mu\left(2\mu + (1-\mu)\ln\left(\frac{1-\mu}{1+\mu}\right)\right)}{r(1-\mu^2)\ln\left(\frac{1-\mu}{1+\mu}\right) + 2\mu\left(2r\mu + (1-\mu)(r-c)\right)}. \tag{9}$$

In the following, we analyze the impact of reduced search cost. Note that only Π_c depends on search cost, and profits under collusion and deviation are independent of the search cost. As $\frac{\partial \Pi_c}{\partial c} > 0$, it follows immediately that $\frac{\partial \bar{\delta}}{\partial c} > 0$. Hence, a reduction of search cost facilitates collusion as the punishments profits are lower if a deviation occurs. It is interesting to note that, on the one hand, a reduction in search cost tend to reduce prices in the static game, but on the other hand, tend to make collusive outcomes more likely in the dynamic game.

The following proposition summarizes the impact of search cost on the incentives to collude:

Proposition 2. A reduction of search cost stabilizes collusion.

Treatment	Communication	Search cost	participants	# groups
LowFix	no	$c = 0.5$	40	10
HighFix	no	$c = 2$	36	9
LowCom	yes	$c = 0.5$	20	5
HighCom	yes	$c = 2$	24	6

Table 1: Treatments

3 Experimental design and procedures

We analyze the effect of a reduction of search cost in concentrated markets with repeated interaction. Therefore, we vary the level of search cost and whether or not seller communication is allowed.

Experimental markets consist of 4 participants, 2 sellers and 2 buyers. Sellers produce at zero costs and set an integer price in $[1, 10]$. Buyers have an inelastic demand up to a reservation value of $r = 15$. Because there is no outside option, buyers always purchase one unit of the good.[3] There are two types of buyers in our experiment, shoppers and non-shoppers. With a probability of 25% a buyer is a shopper in a specific period, $\mu = 0.25$, which means the buyer observes prices of both sellers at zero costs. Buyers are non-shoppers with a probability of 75%, i.e. search is costly. Buyers search sequentially, i.e. upon observing the price of a randomly chosen seller they decide whether they want to invest search cost c in order to obtain price information of both sellers.

Each period is divided in three stages. In the first stage, sellers make their price decision and buyers determine their search strategy. We gave buyers a list of all possible prices and they had to decide for each of the prices whether they would invest in search if they observed that price.[4] In the second stage, buyers get informed if they are shoppers or non-shoppers and make their purchase decision. According to their search strategy from stage one, non-shoppers get either price information of one or both sellers. Shoppers observe prices of both sellers which is costless for them and indepen-

[3] We chose a valuation above the maximum price to ensure positive payoffs for buyers even if the incurred search cost is high.

[4] We implemented the strategy method (Selten, 1967) to obtain the complete search strategy of buyers.

dent of their search strategy. Buyers purchase one unit of the good from either of the sellers. Finally, sellers and buyers receive feedback on their earnings in the third stage. Sellers either sell 0, 1 or 2 units at the chosen price. Buyers obtain their valuation minus the price of the chosen seller. Additionally, non-shoppers have to pay the search cost c if they decided to invest in search.

At the beginning of every session, participants were randomly assigned to be a seller and buyer, respectively. The role of participants was kept constant during the entire experiment. Buyers and sellers remained in the same market throughout the experiment, i.e. we implemented a fixed matching protocol.[5] The experiment consisted of at least 20 periods and a random stopping rule of 50% was implemented afterwards. A priori, we randomly determined the number of periods to be 21 which was the same for all sessions.

In our four treatments we varied the level of search cost (high or low) and whether seller communication is allowed. This results in a 2 by 2 design summarized in Table 1. In the low cost treatments we set search cost $c = 0.5$ and we determined high search cost to equal $c = 2$. In the communication treatments, sellers were allowed to engage in private communication with their competitor before they make their price decisions. Sellers' communication was not structured and could not be observed by the buyers. The pre-play communication phase lasted for 60 seconds in the first five periods, 45 seconds afterwards and sellers could not exit this stage before time expired.

All sessions were run in the DICElab at the University of Düsseldorf and took about one hour. Participants were invited using ORSEE (Greiner, 2015) and the experiment was implemented using the software z-Tree (Fischbacher, 2007). The appendix contains an English translation of the instructions. Subjects received a show-up fee of 4 EUR and could earn additional amounts during the experiment. On average, participants received 14.50 EUR. In total, 120 subjects participated in our experiment. No subject participated in more than one session and none of the subjects had participated in a similar

[5] In addition, we ran 3 sessions implementing a random matching procedure where markets were randomly re-matched in each period. The results are by and large the same as obtained results with fixed matched markets.

	low search cost	high search cost
Average price in static game	2.0	6.81
Price interval in static game	[2.0, 2.0]	[6.0, 8.0]
Critical discount factor	0.23	0.39

Table 2: Predictions

Treatment	*LowFix*	*HighFix*	*LowCom*	*HighCom*
Price	5.37	5.25	8.96	8.70
(Std Dev)	(1.94)	(1.37)	(1.31)	(1.48)
Transaction price	4.60	4.90	8.84	8.59
(Std Dev)	(1.43)	(1.19)	(1.33)	(1.57)
Collusive intensity	1.69	-0.23	3.48	0.28
Search frequency	62.81%	16.67%	43.75%	23.96%
Search effort	0.32	0.31	0.22	0.45
CS	10.15	9.86	6.00	6.03
(Std Dev)	(1.49)	(1.36)	(1.37)	(1.65)

Table 3: Main results

experiment before.

Table 2 provides the predictions given our parameter choices. The predictions also take into account that in the experiment the price is a discrete variable, ranging from 1 to 10.

4 Experimental results

This section presents the experimental results. Table 3 provides an overview of the main results. To account for learning effects, we exclude the first 5 periods. Throughout the paper we employ non-parametric tests where the number of independent observations corresponds to the number of matching groups.[6]

[6]Tables 5 and 6 in the appendix provide an overview over all statistical tests.

4.1 Price setting

We start by analyzing sellers' price choices. In Table 3 we report average posted prices and transaction prices.

Average posted and transaction prices

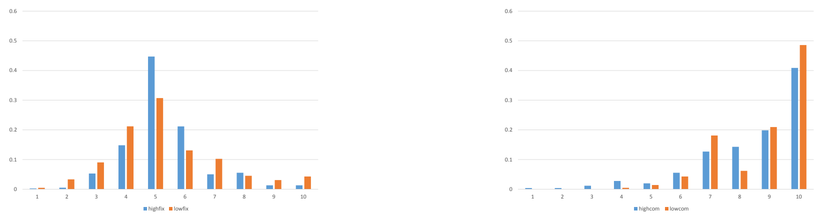
The first main finding is that varying the level of search cost does not lead to significant changes in average prices (independent of whether seller communication is allowed). As can be seen in Table 3, mean posted and mean transaction prices are slightly larger with lower search cost, but these differences are not significant (p-value of 0.71 and p-value of 0.46, for posted prices and p-value of 0.39 and p-value of 0.41 for transaction prices, Mann-Whitney U test).

Prices, however, vary with communication for both levels of search cost. Average prices are lower without communication. For instance, with low search cost the price rises from 5.37 to 8.96 when seller communication is allowed (p-value of < 0.01, Mann-Whitney U test). We observe the same pattern with high search cost and also when we consider transaction prices. The finding that seller communication leads to higher prices and better seller coordination is in line with existing studies (e.g. Fonseca and Normann, 2012, Cooper and Kühn, 2012, Harrington et al., 2016). We find this effect is also present in a search market environment where buyers are active participants in the experiment.[7]

Result 1. i) Reducing search cost has no effect on average posted and transaction prices. ii) Seller communication leads to higher posted and transaction prices in search markets.

Comparing the observed average price with the predictions of the static game, we calculate the intensity of collusion as $(p_{obs} - p_{static})/p_{static}$, which is reported in Table 3. Without communication we find that for high search cost observed prices are lower than theory predicts, yielding an intensity of

[7]We note that the aforementioned findings are stable over time. See Figure 5 in the appendix where we show posted prices over time for each treatment.



(a) No communication

(b) Communication

Figure 1: Price distributions

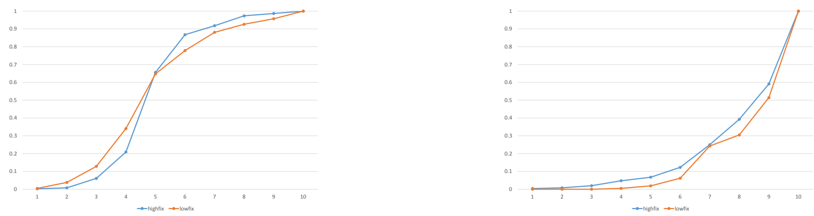
collusion of -0.22. With low search cost, observed prices exceed the prediction raising the intensity of collusion to 1.69. We observe a similar result when sellers can communicate. With either level of search cost, the average price exceeds the competitive prediction, but again the collusive intensity is higher with a lower search cost. Hence, reducing search cost seems to raise the incentives to collude when compared to the theoretical benchmark in the one-shot game.

Result 2. The collusive intensity is higher with lower search cost.

Price dispersion

So far we only looked at average prices. However, to understand buyers' incentives to invest in search, it is important to examine to which degree prices are dispersed.

Figure 1 shows the price distributions across treatments. The left panel displays price frequencies for treatments without communication and the right panel shows the case with seller communication. In line with the previous result, we observe that with seller communication the entire price distribution is shifted to the right. The modal price chosen by sellers is the monopoly price of 10 with communication and a price of 5 without the option to communicate (for both levels of search cost). Figure 2 provides an alternative representation by displaying the cumulative price distributions. Without communication we see that the cdfs with high and low search costs intersect implying more price dispersion with a lower search



(a) No communication (b) Communication

Figure 2: Cumulative price distributions

cost level. When sellers can communicate, the cdfs are close and do not intersect.

We conduct Kolmogorov-Smirnov tests in order to formally compare the price distributions between treatments.[8] The tests confirm communication to have a highly significant impact on the distribution of prices, irrespectively of the level of search cost (p-values of < 0.01, Kolmogorov-Smirnov test). In addition, the level of search cost affects the dispersion of prices if sellers cannot communicate. Without communication, lower search cost increase the dispersion of prices (p-values of < 0.01, Kolmogorov-Smirnov test). When communication is allowed, differences according to the level of search cost disappear (p-value of 0.30, Kolmogorov-Smirnov test).

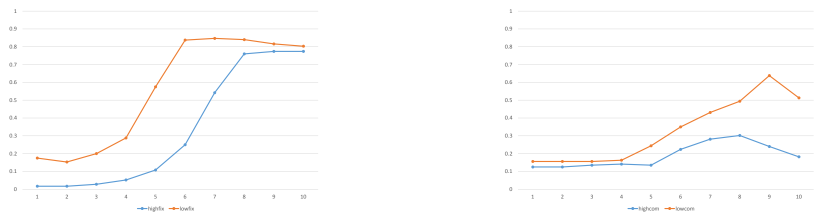
Result 3. i) Without communication, prices are more dispersed with a lower level of search cost. ii) Seller communication decreases price dispersion.

4.2 Search strategies

With our experimental design we are able to observe the entire search strategy of buyers, i.e., we can observe for every possible price p whether or not the buyer would want to invest in search.

Figure 3 shows the buyers' search strategies for all treatments. It can be clearly seen that, for a given price, a buyer is more likely to search if search cost is lower. This accords with basic intuition and holds both for the treatments with and without seller communication.

[8]For a summary of the results see Table 6 presented in the Appendix.



(a) No communication (b) Communication

Figure 3: Search strategies

Treatment	*LowFix*	*HighFix*	*LowCom*	*HighCom*
Cut-off strategy	76.25%	86.46%	68.75%	64.06%
Cut-off price	3.84	6.55	7.55	9.02
(Std Dev)	(1.86)	(1.64)	(2.02)	(1.94)

Table 4: Cut-off strategies

We note that in treatments where sellers can communicate incentives to invest in search are lower.[9] In particular, the effect is strong for large prices (8 to 10). For instance, when search cost is high, the probability of searching when observing a price of 10 drops from around 80% without communication to less than 20% with communication. For the treatments with low search cost, there is also large drop in the search probability. Moreover, it is interesting to observe that, for high prices, the search probability is decreasing as the price rises, an effect that cannot be observed without communication. These findings are consistent with buyers expecting coordination on prices. If buyers expect sellers to successfully coordinate on high prices, there are clearly less benefits from search.

Thus, we summarize our findings.

Result 4. i) Lower search cost lead to larger search incentives. ii) There are smaller incentives to search with communication.

[9]Buyers do invest slightly more in search for very low prices (1 to 3) when sellers can communicate, however, those prices are never chosen by sellers in the treatments with communication.

In the one-shot game, theory predicts that buyers apply a cut-off search strategy when sellers compete. That is, up to a cut-off price a buyer should not invest in search but should always invest if the price exceeds this threshold. Table 4 displays the share of searches that use a cut-off strategies in each treatment. Without communication there is a large share of cut-off strategies, but with communication the use of cut-off strategies is much lower. With low search cost the percentage is 76.25% compared to 68.75% when communication is allowed. With high search cost, the difference is more pronounced and decreases by more than 20%, from 86.46% in *HighFix* to 64.06% in *HighCom*. As discussed before, one potential explanation for the lower use of cut-off strategies might be successful price coordination when sellers talk. If buyers expect sellers to coordinate on high prices, there is little reason to search. However, lower prices might be interpreted as a breakdown of price coordination increasing the incentives to search.

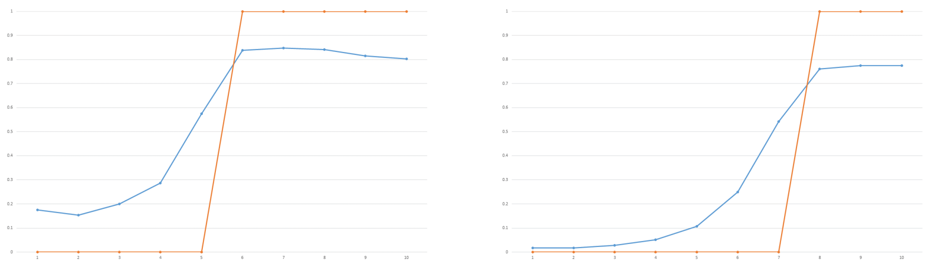
If cut-off strategies are used, we find that the cut-off price is significantly larger with communication (p-value of < 0.01, Mann-Whitney U test) which is consistent with our previous findings that incentives to search are smaller with communication.[10] Without communication, the cut-off price is larger with higher search cost (p-value of < 0.01, Mann-Whitney U test) and with communication we do not obtain significant differences (p-value of 0.36, Mann-Whitney U test).

Result 5. i) Communication leads to less frequent use of cut-off strategies and, if cut-off strategies are used, increases the cut-off price. ii) Without communication, lower search cost decrease the use of cut-off strategies and decrease the cut-off price

4.3 Gains from search and consumer surplus

In this subsection, we consider the implications for consumer surplus (CS) which takes transaction prices and search efforts into account. Until now we have analyzed the search strategy but did not report to what extent search is actually taking place.

[10]For a summary of the results see Table 5 presented in the Appendix.



(a) *LowFix* (b) *HighFix*

Figure 4: Comparison of optimal and observed search strategies

As can be seen in Table 3 lowering the search cost increases the frequency of search. Lower search cost lead to an increase in the search propensity from 16.67% to 62.81% without communication, this difference is highly significant (p-value of < 0.01, Mann-Whitney U test). With communication the fraction rises from 23.96% to 43.75% which is not significant (p-value of 0.93, Mann-Whitney U test). Communication decreases the search frequency with low costs, however, the difference turns out to be insignificant (p-value of 0.60, Mann-Whitney U test). In contrast, with high search cost the introduction of communication raises the frequency of search insignificantly (p-value of 0.23, Mann-Whitney U test).

Whether or not the investment in search pays out, depends on the price level and the distribution of prices. Our design allows to analyze whether the observed search strategies are indeed optimal given sellers' pricing strategies. Without seller communication, we calculate the average potential gain of search.[11] The resulting optimal search strategy is displayed in Figure 4, *LowFix* in the left panel and *HighFix* in the right panel. The figures reveal that for both levels of search cost a cut-off strategy is the optimal strategy for buyers. The optimal cut-off price is higher for high search cost. Whereas search pays from an observed price of 6 in the low cost treatment, buyers should search for price above 8 when search cost is high. While the observed search strategies (also displayed in Figure 4) is roughly in line with optimal search, there are some differences. In particular, the comparison reveals that there is too much search at low prices and too little search for

[11]For each buyer in every period we calculated whether it would have been beneficial to invest in search or not. Taking the average gain of searching we derived the optimal search strategy.

high prices. In particular, when search cost is low, there is too much search at low prices.

When seller communication is allowed we find that search is never optimal, given the observed pricing strategies, that is, at no price does the expected gain of search outweigh the cost. This finding holds for both levels of search cost. Thus, with seller communication we always observe excessive search.

Result 6. i) Without communication, reducing the level of search cost leads to more frequent search. With communication, there is no significant effect on the search frequency. ii) Without communication, there is too much search at low prices, but to little search at high prices. With communication, there is always too much search.

We can calculate the search effort incurred by non-shoppers by multiplying the search propensity (only for non-shoppers) with the search cost. As demand is inelastic in our setup, the search effort is also a measure of total welfare in this market. Our results show that without seller communication the search effort is independent of the search cost (p-value of 0.46, Mann-Whitney U test). That is, the benefits of lowering the search cost is entirely forgone by the higher search rate. With seller communication, we observe a decrease in search effort from 0.45 to 0.22, but this is not significant (p-value of 0.14, Mann-Whitney U test).

Examining the effect of lowering the search cost on consumer surplus we find that both with and without seller communication consumer surplus does not significantly increase with lower search cost (p-value of 0.22 and p-value of 0.86, Mann-Whitney U test). This is consistent with our finding that average prices do not significantly change. The change in search frequency seems to be outweighed by the level of search cost. Finally, as expected, communication with significantly higher price levels leads to a sharp decrease in consumer surplus (p-value of < 0.01, Mann-Whitney U test).

We summarize the effects of search cost reductions on consumer and total welfare.

Result 7. i) With and without communication, reducing the level of search cost has no effect on total search efforts. ii) With and without communication, reducing the level of search cost has no effect on consumer surplus.

Taken together, our findings suggest that policy interventions which aim at raising competition by lowering consumer search cost may not be effective in markets where industry concentration is high. We do not find evidence that consumers are better off. Neither do we observe higher total welfare as measured by search effort paid by buyers.

5 Conclusion

In many markets recent policies aim at reducing consumer search cost. Examples include telecommunication, banking, energy or gasoline markets. Via such interventions, policy makers hope to improve consumers' information and thereby also increase the competitiveness of markets. Many of the aforementioned industries are also characterized by a high market concentration. This paper experimentally analyzes the effects of search cost reductions in concentrated industries by focusing on duopoly markets.

The results of our experiments suggest that market interventions with the aim to decrease consumer search cost are not an effective tool to improve market performance. While we find that consumers do search more intensively when search cost is reduced, we do not observe lower prices. On average, prices with low and high search costs do not differ, but display a larger variation with lower search costs. As a result, consumer surplus does not differ across different search cost levels.

We are also studying markets where sellers are able to communicate. In line with existing studies, we find prices are on average higher, but again do not depend on the level of the search cost. Interestingly, in market where sellers can coordinate more easily, consumers are less likely to invest into search efforts and the search intensity does not depend on the search cost.

As many markets, where interventions to increase consumer information are discussed, are characterized by a high market concentration we focused on the two-seller case in this paper. It would be interesting for future research such interventions in markets with a larger number of sellers and higher intensity of competition.

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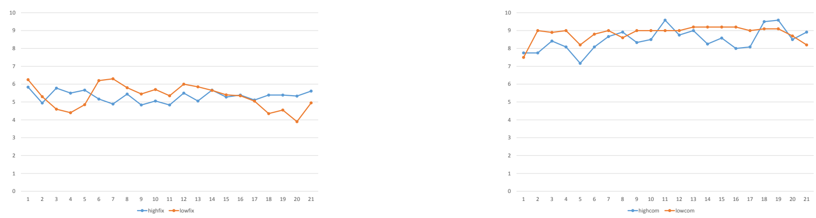
Appendix A

Further tables and figures

	Price	Transaction price	Cut-off price	CS
LowFix vs. *HighFix*	0.71	0.39	< 0.01	0.22
LowCom vs. *HighCom*	0.46	0.41	0.36	0.86
LowFix vs. *LowCom*	< 0.01	< 0.01	< 0.01	< 0.01
HighFix vs. *HighCom*	< 0.01	< 0.01	< 0.01	< 0.01

Table 5: p-values of pairwise comparisons with Mann-Whitney U test



(a) Average prices over time with fixed matching

(b) Average prices over time with fixed matching and communication

Figure 5: Average prices over time

	no communication	vs.	communication
low search cost		< 0.01	
vs.	< 0.01		0.30
high search cost		< 0.01	

Table 6: Comparison of price distributions: p-vaules of the two-sample Kolmogorov-Smirnov test

Appendix B

Instructions

The following instructions were originally written in German.

Welcome to this experiment! Please read the instructions carefully. The experiment is fully anonymous, i.e., you do not know with whom of the participants you interact. We do not save any personal data in connection with your name.

Depending on your own and the other participants' decisions during the experiment, you can earn experimental currency units (ECU). At the end of the experiment, ECUs are converted into Euro at an exchange rate of 15 ECUs = 1 Euro and will be paid to you in cash. For participating in this experiment, you earn 4 EUR plus the payoff you earn during the experiment.

Please note that you are not allowed to talk to any other participants of the experiment. Please raise your hand if you have any questions regarding the experiment and we will come to your place.

Structure of the experiment

In this experiment, you either take the role of a seller or a buyer in a market. The role is randomly assigned at the beginning of the experiment and communicated to you. You keep your role over the entire experiment.

In the market, there are two sellers and two buyers. Before the experiment starts, two sellers and two buyers are randomly matched. Each constellation is fixed in all periods of the experiment, that is, in all periods you interact with the same participants.

Each seller intends to sell exactly one unit of the product to every buyer. Every buyer intends to buy exactly one unit of the product. Buyers neither have the possibility not to purchase the product nor to buy more than one unit of the product.

Every period of the experiment consists of three stages:

Stage 1:

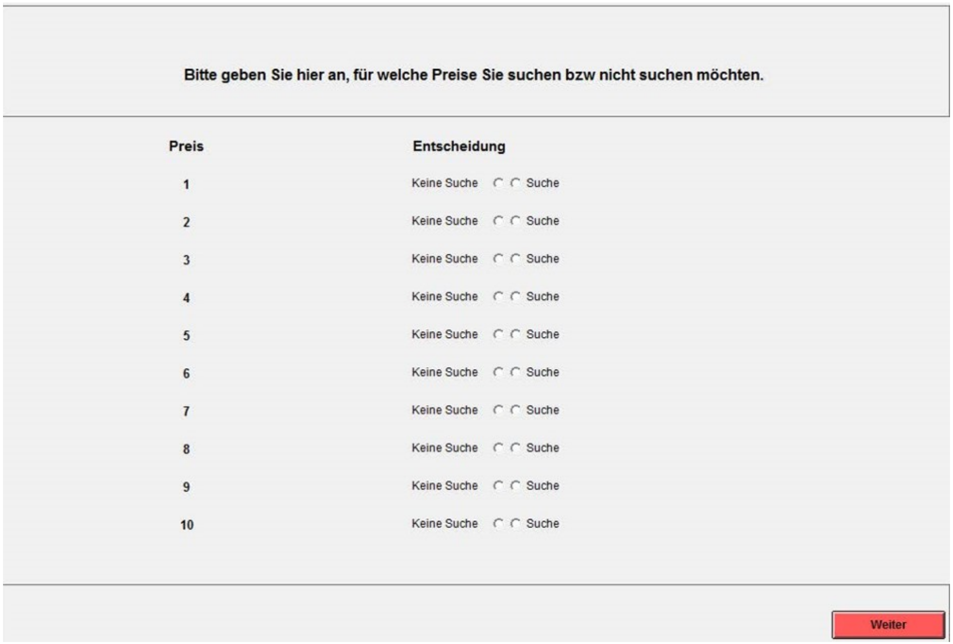
Decision of sellers

In every period of the experiment, both sellers independently choose their price. The chosen price has to be an integer between 1 and 10 ECU.

[*The following additional instructions were only given in the treatment where communication between sellers was allowed*: Before setting a price, sellers have the opportunity to communicate via a chat window. At the beginning of each round, sellers is given time to chat. In the first five periods, communication is restricted to one minute, in the following rounds, communication is restricted to 45 seconds. Buyers neither can read the communication nor can they communicate with the sellers themselves.]

Decision of buyers

Buyers decide how well they wish to be informed about seller's prices. In stage 2, sellers will obtain the price of one randomly drawn sellers. However, sellers have already to decide in stage 1 for which posted prices they will invest in search. In case you will be assigned to the role of a buyer, the following screen will be shown in stage 1:



In the left column, all possible prices are displayed. In the right column, you can either decide in favor or against search for any price. You have to choose either "search" or "no search".

In stage 2, you are informed about the price of a randomly determined seller. If you decided to invest in search at the posted price in stage 1, you additionally obtain the price of the other seller and have to pay c ECU. In case you decided against search at that price, you do not receive any additional price information, but you also do not have to incur additional costs.

Stage 2:

In this stage only buyers make decisions.

With a probability of 25%, you obtain price information of both sellers free of costs and you can decide between both sellers' products. In this case, you have no additional costs, independent of your search decisions in stage 1.

With a probability of 75%, you only obtain price information of one seller without costs. Which of the sellers' prices you obtain is randomly determined. Your further options depend on your decision in stage 1. In case, in stage 1, you decided to obtain additional price information at the posted price, you also obtain the price of the other seller. You incur search cost of c. You can decide which of both products to purchase. In case, in stage 1, you decided not to invest in additional information at the posted price, you do not obtain additional price information. But also you do not incur any additional cost.

Stage 3:

At the end of each period you obtain information on your payoff.

Payoff of buyers:

The payoff of a buyer depends on the purchase decision, the purchase price, as well on the potential cost for receiving additional price information. The buyer earns the following payoff:

payment buyer=15-price-search cost

Payoff of sellers:

The payment of sellers depends on the chosen price and the purchase decision of buyers:

payment seller= price * sold quantity

If no buyer decided in favor of the sellers product, the seller would receive zero payoff in that period.

Example 1:

You are a seller and choose a price of 6 ECU. The randomly assigned buyer decided in stage 1 not to invest in search for a price of 6 ECU. The other buyer obtained randomly the information about prices of both sellers and decided to purchase your product. You sold 2 units of your product at a price of 6 ECU which sums up to a profit of 12 ECU for this period.

Example 2:

You are buyer and you have to decide for each price to invest in search or not. You decide not to search, if prices are between 1 and 5 ECU and for prices equal to or larger than 6, you decide to incur the search cost of c and obtain price information of both sellers.

In stage 2, you observe the price of seller 2 which is 7 ECU. Because you decided to search for a price equal to or above 6 ECU, you obtain information on the price of seller 1 as well. The price of seller 1 is 5 ECU. In stage 2, you decide to purchase the product of seller 1, buy one unit of the product, and pay a price of 5 ECU. In total, your payment for this period is $15 - 5 - c = 10 - c$ ECU.

End of the experiment

The experiment will be repeated for at least 20 times. At the end of period 20 (and in the possibly following periods) a random draw determines whether another period will follow. With a probability of 50%, another period follows, otherwise the experiment ends. As already stated above, in each round, you will interact with the same participants. At the end of the experiment, your earnings will be paid out to you in cash. Your earnings comprises the show-up fee and the points you have earned during the experiment.

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