**Preprints of the
Max Planck Institute for
Research on Collective Goods
Bonn 2016/18**

Internal conflict, market uniformity, and transparency in price competition between teams

Michael Kurschilgen
Alexander Morell
Ori Weisel

MAX PLANCK SOCIETY

Preprints of the
Max Planck Institute
for Research on Collective Goods Bonn 2016/18

Internal conflict, market uniformity, and transparency in price competition between teams

Michael Kurschilgen, Alexander Morell, Ori Weisel

November 2016

Max Planck Institute for Research on Collective Goods, Kurt-Schumacher-Str. 10, D-53113 Bonn
http://www.coll.mpg.de

Internal conflict, market uniformity, and transparency in price competition between teams

Michael Kurschilgen[#§], Alexander Morell[§], Ori Weisel[+]

[#]School of Management, Technical University of Munich

[§]Max Planck Institute for Research on Collective Goods, Bonn

[+]Coller School of Management, Tel Aviv University

November 23, 2016

Abstract

The way profits are divided within successful teams imposes different degrees of internal conflict. We experimentally examine how the level of internal conflict, and whether such conflict is transparent to other teams, affects teams' ability to compete vis-à-vis each other, and, consequently, market outcomes. Participants took part in a repeated Bertrand duopoly game between three-player teams which had either the same or different level of internal conflict (*uniform* vs. *mixed*). Profit division was either *private-pay* (high conflict; each member received her own asking price) or *equal-pay* (low conflict; profits were divided equally). We find that internal conflict leads to (tacit) coordination on high prices in uniform private-pay duopolies, but places private-pay teams at a competitive disadvantage in mixed duopolies. Competition is softened by transparency in uniform markets, but intensified in mixed markets. We propose an explanation of the results and discuss implications for managers and policy makers. (D43, L22, C92)

Keywords: Organizations, Conflict, Sharing Rules, Competition, Heterogeneity, Transparency, Experiment

1. Introduction[1]

Organizations and firms vary substantially in how they incentivize employees and business units, and in the level of internal distributional conflict that different incentive structures impose. For example, remunerating business units according to their returns may motivate personnel, but at the same time induce conflict within the firm's supply chain (e.g., between different business units). Stronger vertical integration, on the other hand, may mitigate such conflicts and allow an organization to think and act "as one". In competitive markets, organizations with different incentive structures, and different degrees of internal conflict, coexist and compete with one another. The precise nature of each organization's incentive structure, and, hence, the existence of internal distributional conflicts, may be more or less visible to competitors. This paper investigates the effect of such internal conflicts on the ability of organizations to compete with other organizations which may, or may not, face similar conflicts.

To tackle the research question, we conduct a laboratory experiment in which two organizations compete repeatedly on price in a simple market game (Bornstein & Gneezy, 2002; Dufwenberg & Gneezy, 2000). Each organization is modeled as a three-player team. Teams can be of two different types, reflecting two stylized extremes of a large spectrum of distributional conflict that organizations may face. At one end of the spectrum are *equal-pay (E)* teams in which profits are divided equally among all members of the team and thus distributional conflict is absent by design. At the other end of the spectrum are *private-pay (P)* teams, in which profits are distributed according to a "who asks the most, gets the most" rule. Distributional conflict arises as soon as certain members persistently claim larger shares than others. In a series of treatments, we vary whether teams face a competitor of the same type (*uniform market*) or of a different type (*mixed market*), and whether the types are mutually known (*transparent market*) or not (*opaque market*).

For markets that are both uniform and transparent extant work has shown that, somewhat paradoxically, equal-pay teams compete more aggressively than private-pay teams (Bornstein et al., 2008; Bornstein & Gneezy, 2002). In uniform markets, internal distributional conflict serves as a useful tool to tacitly coordinate on higher and thus more profitable prices. We show that these results also extend to opaque markets. In contrast, the same individualistic incentives become a competitive disadvantage in

[1] We thank Olga Gorelkina, Sebastian Georg, Oliver Kirchkamp, Botond Köszegi, Christoph March, Ivan Soraperra and Bert Willems for helpful comments on earlier versions of this paper.

mixed markets as equal-pay teams systematically set slightly lower prices and thus accumulate substantially more profits than the private-pay teams. Interestingly, we find that in mixed markets transparency plays a central role in determining price levels. With transparency, private-pay teams become more aggressive and adapt their prices downward. Without transparency, it is the equal-pay teams who become less aggressive and adapt their prices upward.

2. Related literature and current contribution

The present paper mainly relates to three streams of literature: (a) competition between teams, (b) teams and their optimal organization, and (c) the effects of information on competition. In this section we briefly mention a number of key results from each stream, and explain how we contribute to, and expand upon, each.

(a) Competition between teams

While there is growing interest in the experimental study of both competition (Fugger et al., 2015; Huck et al., 2016; Potters & Suetens, 2013) and the performance of differently structured teams (Hoogendoorn et al., 2013; Weber & Camerer, 2003), the literature that considers competition between teams rather than between individuals remains relatively small. A prevailing result in this literature is that competition between teams can serve to increase efforts and mitigate free riding within teams (Abbink et al., 2010; Bornstein et al., 2008; Cason et al., 2012; Leibbrandt & Sääksvuori, 2012; Nalbantian & Schotter, 1997; Sutter & Strassmair, 2009). Recently, Brookins et al. (2015) have shown that teams exert higher effort in contests with similarly skilled competitors.

Only a few papers have studied how the internal organization of competing groups affects competitive outcomes (see Sheremeta (2015) for a review). Bornstein and Gneezy (2002) and Bornstein et al. (2008) find that, in uniform contests, competition between equal-pay teams is fiercer than competition between private-pay teams, convincingly demonstrating that the sharing rules that govern profit distribution among members of the winning team matter. Abbink et al. (2010) show that introducing intra-group punishment (inefficiently) increases teams' aggressiveness in inter-group contest. Sääksvuori et al. (2011) extend the analysis of intra-group punishment to mixed contests, and show that a group with punishment opportunities is competitively superior to a group without such opportunities. Similarly, introducing intra-group communication leads to increased efforts and decreased efficiency in uniform contests (Cason et al., 2012). In mixed contests, groups with intra-group communication have a competitive advantage over groups without communication (Cason, Sheremeta, & Zhang, 2015).

We broaden the analysis in two crucial dimensions. First, we study mixed markets in which competitors have different internal profit-sharing rules, and, consequently, different degrees of internal distribution conflict. Second, acknowledging that the notion of mixed contests de-trivializes the epistemic nature of the competition—in the sense that it is no longer obvious that each competitor knows how the other is organized—we manipulate the transparency of the internal profit-sharing rules. We consider transparent and opaque contests, in which the profit-sharing rule of the competitor is either known or unknown, respectively.

(b) Teams and their optimal organization

There is a large literature studying the optimal way of structuring teams. Alchian and Demsetz (1972) point out that in certain professions—lawyers, for example—organizing production by establishing profit-sharing, self-monitoring teams can increase production efficiency by circumventing the need (present in hierarchical firms) to centrally monitor individual efforts. In a similar vein, profit-sharing among team members provides insurance against idiosyncratic shocks to human capital (Lang & Gordon, 1995) and helps committing to high quality when it cannot be easily assessed by customers (Levin & Tadelis, 2005). A related body of work deals with the way profits are shared. In particular, the commonly employed equal-profit sharing rule has been shown to have both advantages and disadvantages: it provides optimal incentives for inequity-averse team members to exert effort (Bartling & von Siemens, 2010) and protects the team against sabotage (Harbring & Irlenbusch, 2011), but fails to optimally insure team members against income risk (Wilson, 1968), and may hinder efficiency by inducing teams to remain too small and uniform (Farrell & Scotchmer, 1988; Kräkel & Steiner, 2001).

The extant literature on optimal organization of teams has predominantly focused on the problem of team production. Yet it has given little attention to the interaction between teams' internal structure (e.g., the specific way by which profits are shared) and the way that inter-team competition unfolds, even less to situations where competing teams differ in their internal organization, and none to transparency considerations.

(c) Information about the competitor

There has been considerable research on the effects of information about a competitor's costs or demand. Available information on competitors' costs may facilitate the search for the lowest price (Stigler, 1961), shift production to the more efficient producer in a Cournot market (Shapiro, 1986), or simply foster collusion (Grether & Plott, 1984; Schelling, 1960; Stigler, 1964). Mason and Phillips (1997) varied experimentally whether competitors in a Cournot duopoly were informed (or not) about their respective competitor's costs of production. In their uniform markets, more information increased collusion, while in their mixed markets competitors behaved roughly in accordance with the Nash equilibrium predictions, irrespective of the information condition. Argenton and Müller (2012) make the inverse observation in a Bertrand duopoly. In their experiment, complete information about the competitor's profits fosters collusion in markets with asymmetric costs but not in markets with symmetric costs. Merely framing information on internal conflict as information on organizational cost would ignore the broad social dynamic of conflict. This is why we go beyond the existing literature by directly looking at information on the respective competitor's internal incentive structure.

3. Experimental design and procedure

As experimental paradigm we use a repeated Bertrand duopoly game (abstracting from production and trade), in which each of the two competitors consists of a team of three players. The game was introduced by Dufwenberg and Gneezy (2000) for individual players, and modified as a team game by Bornstein and Gneezy (2002). In every period of the game, each member $k \in \{1,2,3\}$ in team $i \in \{1,2\}$ simultaneously states an individual asking price $X_{ik} \in \{2,3,\dots,25\}$. The total asking price of team *i* is denoted by X_i ($X_i = \sum_{k=1}^{3} X_{ik}$). The team with the lower total asking price wins the competition; if the two total asking prices are equal there is a tie.

There are two types of teams, differing by how profits are divided among the three team members. Under an individualistic *private-pay (P)* structure, each team member is paid her *individual* asking price if the team wins, and half her asking price in case of a tie. Under an egalitarian *equal-pay (E)* structure each team member receives the *average* asking price if the team wins, and half the average asking price if there is a tie. In both sharing rules members of the losing team receive nothing.[2] Formally, the payoff of member k in team i in private-pay or equal-pay teams is given in **Table 1**.

Private-pay	Equal-pay
$\pi_{ik}^{P} = \begin{cases} X_{ik}, & X_i < X_j \\ X_{ik}/2, & X_i = X_j \\ 0, & X_i > X_j \end{cases}$	$\pi_{ik}^{E} = \begin{cases} X_i/3, & X_i < X_j \\ X_i/6, & X_i = X_j \\ 0, & X_i > X_j \end{cases}$

Table 1: Payoff Functions.

Table 2 illustrates the experimental setup. In a 3x2 design we vary the composition of the market in terms of the competing teams' sharing rules (P vs. P, E vs. E, P vs. E), and the transparency of these sharing rules. This results in two types of uniform markets where a private-pay team is matched with another private-pay team (PP), or an equal-pay team is matched with another equal-pay team (EE), and in mixed markets where a private-pay team is matched with an equal-pay team (PE). Participants always had information about their own team's sharing rule. In the *transparency* (t) treatments participants were also informed about the sharing rule of the competing team; in the *opaque* (o) treatments they were not.

	uniform	**mixed**
transparent	PPt (N_i=96; N_t=32; N_m=16) EEt (N_i=90; N_t=30; N_m=15)	PEt (N_i=96; N_t=32; N_m=16)
opaque	PPo (N_i=96; N_t=32; N_m=16) EEo (N_i=96; N_t=32; N_m=16)	PEo (N_i=96; N_t=32; N_m=16)

Table 2: Experimental Treatments.

N_i=number of individual participants; N_t=number of teams; N_m=number of markets.

The interaction was repeated for 120 announced periods. The team's composition, sharing rule, and corresponding competitor were determined randomly before the first period and remained constant over all

[2] We label the two internal incentive structures "private-pay" and "equal-pay" since this reflects the nature of the sharing rules. Please note, however, that we did not use any loaded labels in the experimental instructions. Instead, we simply used the terms "Distribution key A" and "Distribution key B".

120 periods. After each period participants received feedback about their own asking price, the total asking price of their team, the total asking price of the other team, their earnings in the period, and their cumulative earnings. Before starting, paper instructions were distributed to all participants in a session. The instructions informed the participants about the two available sharing rules, the time horizon, and the information they would receive on their computer screens during the experiment. The paper instructions for the private-pay teams and for the equal-pay teams treatments were identical; type-specific information was given on-screen. The difference between the paper instructions for the "transparent" and "opaque" treatments was just one single word.[3] There was no possibility of communicating neither within teams nor between teams.

The experiment was computerized using the software z-tree (Fischbacher, 2007) and participants were recruited from a pool of more than 5000 people using ORSEE (Greiner, 2004). Overall, 570 participants took part in 24 experimental sessions at the Bonn EconLab. The average session lasted about 90 minutes and participants earned about €17 on average. Individual payoffs ranged from €3.50 to €47.

4. Theoretical considerations

In the following we discuss some theoretical approaches to predict how the team's type (i.e., its internal incentive structure; P or E), the competitor's type, and the knowledge thereof, may affect behavior.

(a) Nash equilibrium

The unique Nash equilibrium of the stage game is that all participants demand the lowest possible individual asking price, $X_{ik}=2$. This is true regardless of the team's sharing rule (for a more detailed discussion see Bornstein et al. (2008)). Furthermore, the Nash equilibrium is not affected by the competitor's sharing rule or by the knowledge thereof. Thus, the standard game theoretic prediction for the stage game is identical for all our treatments. Since the fact that the game will be played repeatedly for exactly 120 periods was made known to the participants, by backward induction it follows that the stage game equilibrium holds for each period of the repeated game as well.

[3] See Appendix for the paper instructions.

(b) Individual adaptation

Previous results, however, indicate that teams' sharing rules do influence behavior, even when they do not affect the Nash equilibrium. In fact, in markets that are both uniform and transparent, private pay teams set substantially higher prices than equal-pay teams, and thus earn considerably higher profits (Bornstein et al., 2008; Bornstein & Gneezy, 2002).

Bornstein and Gneezy (2002) provide a compelling argument, based on a simple process of individual adaptation, to predict and explain this result. A slightly altered version of their argument is as follows: suppose member k in team i is undecided between a pair of possible prices, $\overline{X}_{ik}$ and $\underline{X}_{ik}$, with $\overline{X}_{ik} > \underline{X}_{ik}$ and $\Delta = \overline{X}_{ik} - \underline{X}_{ik}$. The decision's implication on the team's winning probability is similar whether it is a private-pay team or an equal-pay team—the probability of winning is higher when the asking price is lower. However, private-pay teams and equal-pay teams differ in the way the choice between $\overline{X}_{ik}$ and $\underline{X}_{ik}$ affects the profit of the decision maker herself. Private-pay teams provide a weaker incentive to bid the lower price ($\underline{X}_{ik}$): if the team wins when $\underline{X}_{ik}$ was chosen, member k earns Δ less than what she would have earned had she chosen $\overline{X}_{ik}$ (and had she still won the competition). In contrast, in an equal-pay team k's earnings are decreased by only $\Delta/3$. Thus, a team member's inclination to lower her asking price, at a private cost to herself, in order to increase the team's chances of winning, is lower in private-pay teams than in equal-pay teams. Similarly, the temptation to increase personal profits at a cost to the team's chance of winning is higher in private-pay teams than in equal-pay teams. This argument does not rely on the transparency of the sharing rules. Therefore, we expect to find higher prices in uniform private-pay markets as compared to equal-pay markets, both with and without transparency.

This reasoning is independent of the competitor's type, and is thus relevant to mixed markets as well. Regardless of the competitor's type, members of equal-pay teams have a stronger incentive to opt for lower prices, increasing their team's probability of winning. This is the case for both transparent and opaque markets. The resulting prediction is that equal-pay teams will have a competitive edge over private-pay teams when competing against each other in the same market—i.e. they will win the competition more often—in both transparency conditions.

Even if equal-pay teams indeed win the competition more often, predicting *price levels* in mixed markets is not obvious. Three scenarios come to mind:

(1) low ("equal-pay") prices: in an attempt to compete with equal-pay teams, private-pay teams will be forced to lower their asking prices, resulting in prices similar to those of uniform equal-pay markets.
(2) high ("private-pay") prices: equal-pay teams will seize the opportunity to enjoy higher prices, resulting in prices similar to those of uniform private-pay markets.
(3) intermediate prices: both processes will take place simultaneously, resulting in prices that are higher than prices in uniform equal-pay markets and lower than prices in uniform private-pay markets.

A way to assess the relative plausibility of the scenarios above is to apply learning models which are sensitive to the size of the incentive to lower individual bids. We consider two such models: *reinforcement learning* (Erev & Roth, 1998; Roth & Erev, 1995), a stimulus learning model that takes into account the payoff generated by the player's actions in the past; and *fictitious play* (Brown, 1951), a belief-based model that takes into account players' beliefs about the future actions of others.[4]

Despite the radically different underlying behavioral assumptions, for the uniform markets both models yield strikingly similar predictions: high prices in private-pay markets and low prices in equal-pay markets. For the mixed markets, however, reinforcement learning predicts intermediate prices (scenario 3 above), whereas fictitious play predicts that mainly equal-pay teams will adapt, resulting in high prices (scenario 2 above). Both reinforcement learning and fictitious play are mute with respect to the effect of transparency.[5]

(c) Effect of transparency

In the absence of theory or previous evidence, a straightforward prediction is that transparency helps coordination on the mutually desirably outcome, i.e. high prices. This prediction is based on the intuition that (a) successful coordination requires members of each team to accurately predict the behavior of members of the other team, and (b) accurately predicting the behavior of the other team is easier when there is more information about the other team. The intuition is supported by analogy to the literature on the availability of cost information, which justifies the theoretical predictions of higher prices through more

---

[4] See Appendix B for details.

[5] To the best of our knowledge there are no learning models that are sensitive to the knowledge players have about the payoff function of other players.

information by reference to focal points and mutually coordinated expectations of reasonable outcomes (Grether & Plott, 1984).[6]

5. Results

We first report treatment effects on individual pricing behavior, and then proceed to study the implications for profits.

(a) Pricing Behavior

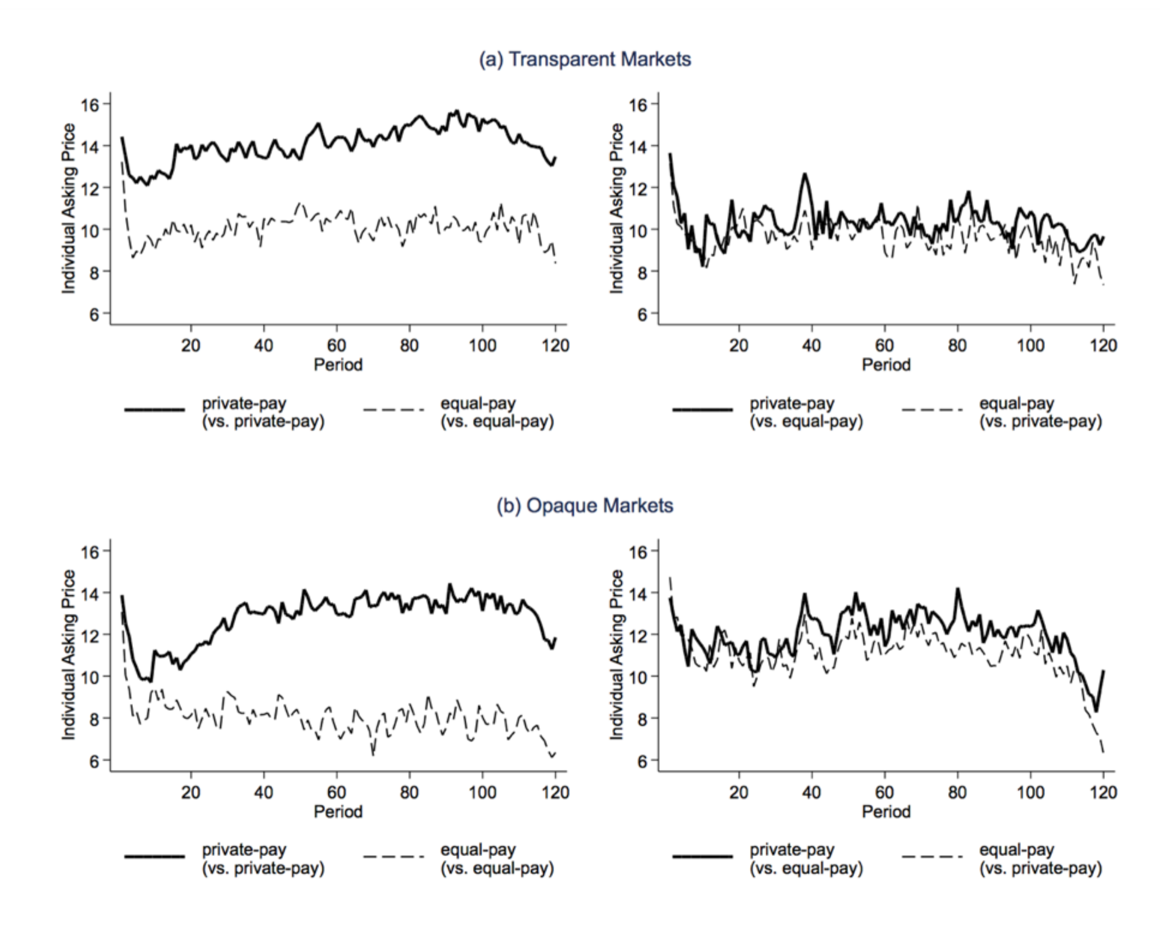

Figure 1: Individual asking prices

[6] It should be noted, however, that in the realm of cost information empirical studies have not corroborated this predicted effect of transparency (see Mason and Phillips (1997), Argenton and Müller (2012)).

The graphs on the left (right) show the uniform (mixed) markets.

Result 1. *Individual asking prices are higher in uniform private-pay markets than in uniform equal-pay markets, both with and without transparency.*

The large difference between private-pay and equal-pay markets in the upper-left panel of Figure 1 (PPt vs. EEt: $p<0.001$, N=31)[7] confirms and corroborates previous findings (Bornstein et al., 2008; Bornstein & Gneezy, 2002). In addition, as depicted in the lower-left panel, we find the difference to be present even when the competitor's sharing rule is unknown (PPo vs. EEo: $p<0.001$, N=32).

Result 2. *Transparency leads (a) to higher individual asking prices in uniform markets but (b) to lower prices in mixed markets.*

When both competitors in the market have the same internal structure, individual asking prices are higher when sharing rules are transparent. This is the case for private-pay markets (PPt vs. PPo: $p=0.046$, N=32) and equal-pay markets alike (EEt vs. EEo: $p=0.044$, N=31). However, the opposite happens when competitors have different internal structures. In this case, both equal-pay teams (E(PEt) vs. E(PEo): $p=0.090$, N=32)[8] and private-pay teams (P(PEt) vs. P(PEo): $p=0.050$, N=32) ask for less when sharing rules are transparent.

Result 3. *When sharing rules are transparent, individual asking prices in mixed markets are as low as in equal-pay markets (scenario 1).*

As can be seen by comparing the two plots in the upper panel of Figure 1, price levels in mixed markets are virtually identical to those in uniform equal-pay markets. This is due to the fact that private-pay teams significantly lower their asking prices (P(PEt) vs. PPt: $p<0.001$, N=32) whereas equal-pay teams do not change their behavior (E(PEt) vs. EEt: $p=0.594$, N=31).

Result 4. *When sharing rules are opaque, individual asking prices in mixed markets are as high as in private-pay markets (scenario 2).*

---

[7] Unless specified otherwise, we report P-values from Mann-Whitney ranksum tests (two-sided) over means per market.

[8] E(PEt) denotes an equal-pay team in a PEt market, etc.

As can be seen in the lower panel of Figure 1, price levels in PEo markets are virtually identical to those in PPo markets. This is due to the fact that equal-pay teams significantly increase their asking prices (E(PEo) vs. EEo: $p=0.002$, $N=32$) whereas private-pay teams do not change their behavior (P(PEo) vs. PPo: $p=0.451$, $N=32$).

The contrast between Results 3 and 4 is striking. They suggest that with transparency the equal-pay teams set the tone whereas without transparency the private-pay teams do so. A plausible explanation for this finding is the relative salience of inter- and intra-group conflict. Members of equal-pay teams only face an inter-team conflict between their team and the competing team. The predetermined equal division of profits among team-members eliminates any intra-team conflict. Members of private-pay teams, on the other hand, additionally face an intra-team conflict, which has opposing behavioral implications. Whereas in the inter-team conflict it is best to ask for a low price in order to outbid the other team and win the competition, in the intra-team conflict a private-pay team member is tempted to ask for a high price in order to reap a higher profit in case of a win.

When members of a private-pay team are not aware of the competing team's sharing rule (i.e., under opaqueness), they pay more attention to the internal conflict within their own team, leading them to opt for high individual asking prices. Such behavior enables members of the competing equal-pay team to increase their own asking prices to just below those of the private-pay team, such that they still win the majority of the competitions, but at higher prices (and, hence, higher profits). Under transparency, the inter-team conflict becomes more salient, so private-pay team members are driven to lower their individual asking prices in order to successfully compete with the other team, and the result is a market with low prices.

Result 5. *All treatment differences emerge over time.*

The observed differences between our treatments could, in principle, be a result of participants' prior beliefs and expectations about the market they are operating in, of learning and adaptation which take place during the repeated interactions, or both. If prior beliefs and expectations play a role in shaping the behavioral differences between the various treatments, at least some differences should be observed already in the very first period. This, however, is not the case. Asking prices in the first period are not different between the treatments (Kruskal-Wallis, $p=0.765$, $N=570$), indicating that learning and adaptation, and not prior beliefs and expectations, are the source of the behavioral differences between the treatments.

(b) Profits

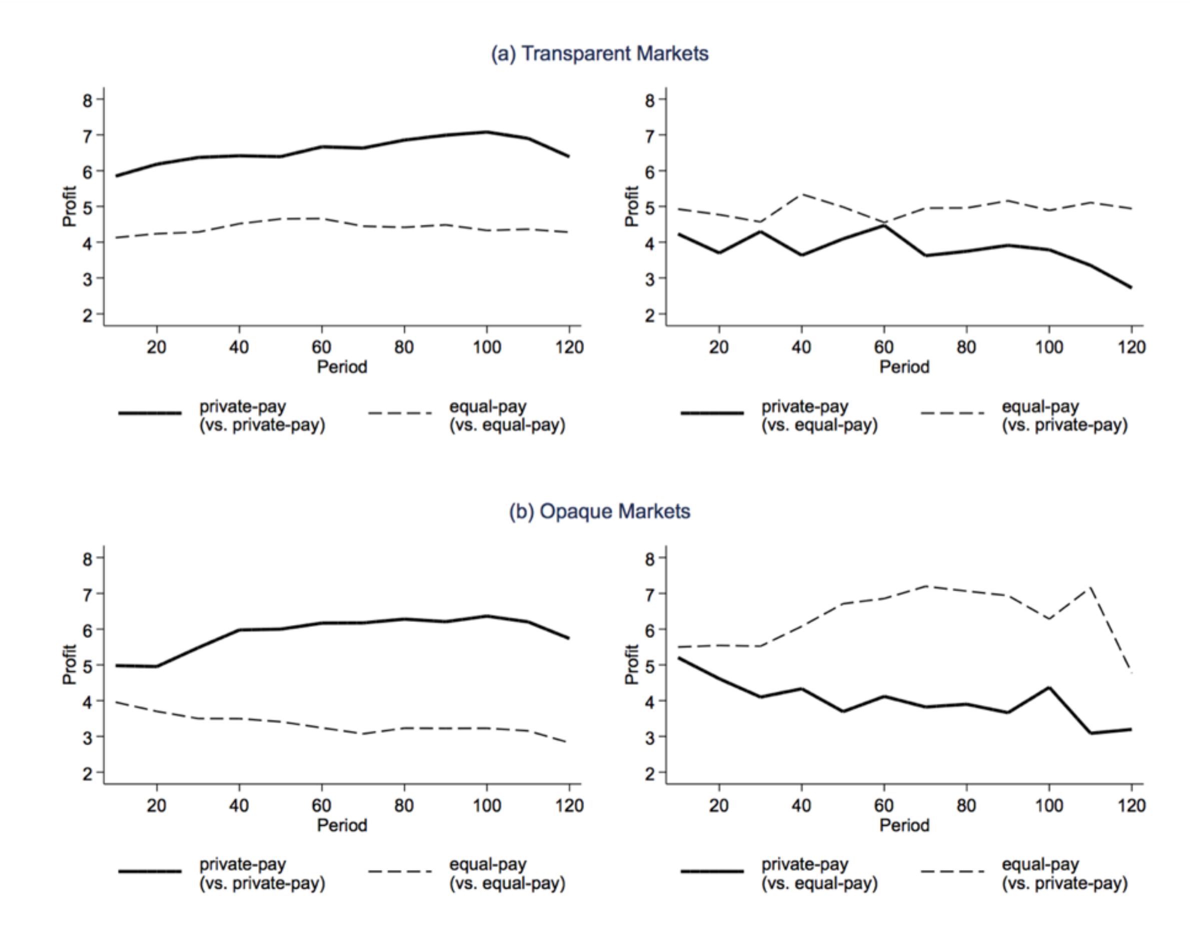

Figure 2: Profits
The graphs on the left (right) show the uniform (mixed) markets. For better readability, the 120 periods are pooled into 12 blocks of 10 periods each.

Result 6. *In uniform markets, private-pay teams have an advantage over equal-pay teams, independent of transparency.*

This result follows directly from result 1. The profits of private-pay teams are 49% higher than those of equal-pay teams in transparent markets, and 76% higher in opaque markets. Thus, in uniform markets, internal distributional conflict serves as a useful tool to tacitly coordinate on higher and thus more profitable prices.

Result 7. *In mixed markets, equal-pay teams have an advantage over private-pay teams, independent of transparency – they (a) ask systematically for slightly less, (b) win substantially more often, and (c) accumulate more profits.*

In mixed markets teams with internal distributional conflict have a considerable competitive disadvantage. As can be seen in both right-hand plots of Figure 1, equal-pay teams manage to systematically set slightly lower prices than their private-pay competitors—both in transparent (E(PEt) vs P(PEt): $p=0.020$, $N=16$) and in opaque markets (E(PEo) vs P(PEo): $p<0.001$, $N=16$)[9]. As a result, equal-pay teams win significantly more often—both in transparent ($p=0.006$) and in opaque markets ($p<0.001$), and, as shown in Figure 2, earn significantly higher profits—30% higher in transparent ($p=0.017$) and 57% higher in opaque markets ($p=0.001$).

(c) Meta Games and Strategic Implications

In the real world it is reasonable to assume that internal incentive structures are determined endogenously, for instance by the team's manager, and not imposed exogenously (as in the experiment reported here). Assuming that the choice of incentive structure is indeed endogenous, our results define two meta games—for the transparent and opaque cases, respectively—in which each team chooses an incentive structure, and then the teams compete in a repeated Bertrand duopoly game, as in our experiment. Using our results to predict the outcome of the repeated game, the resulting meta games are described in Table 3.

The nature of the meta games is critically influenced by whether internal incentive structures are transparent or opaque. When incentive structures are transparent the resulting meta-game is a stag hunt game (i.e., assurance or coordination game) with two pure strategy Nash equilibria; either both managers choose private-pay incentives, or both choose equal-pay incentives, with the uniform private-pay equilibrium being both payoff dominant and risk dominant. In contrast, when internal incentive structures are opaque, the payoffs of the meta-game correspond to a chicken game with two non-symmetric equilibria, where one team chooses equal pay and the other private pay (i.e., the market is mixed). The attractiveness and high profits of the uniform private-pay equilibrium in the transparent case, as opposed to the conflictual nature of the chicken game in the opaque case, suggest that teams should prefer to operate in markets with

[9] For comparisons of private-pay and equal-pay teams within the mixed markets, we report P-values from Wilcoxon signed rank tests (two-sided) over means per team.

transparent sharing rules, and that once they do, they should prefer private-pay sharing rules, reasonably expecting that the competitor will do so too.

Transparent	private-pay	equal-pay
private-pay	6.6 6.6	4.9 3.8
equal-pay	3.8 4.9	4.4 4.4

Opaque	private-pay	equal-pay
private-pay	5.9 5.9	6.3 4.0
equal-pay	4.0 6.3	3.3 3.3

Table 3: Meta Game of Choosing the Team's Internal Incentives:

Values are average period earnings of a team member in the corresponding condition. Bold frames indicate the Nash equilibria.

6. Conclusion

The internal organization of the decision-making unit is often overlooked in the study of economic decisions. This paper goes beyond the small body of previous work which has established that the internal organization of decision making teams plays a crucial role in shaping market outcomes, by analyzing the effect of transparency in markets where competitors may differ in their internal organization structure, namely in their price setting mechanism. Our internal price setting mechanism provides a stylized model of intra-team negotiations over strategic price setting. Depending on how profits are shared, these negotiations can be overshadowed by intra-team conflicts (in private-pay teams), or focus on the inter-team competition (in equal-pay teams).

Our main findings can be summarized by two contrasts: (1) When sharing rules are transparent, prices in mixed markets are as *low* as in uniform equal-pay markets. Yet, when sharing rules are opaque, prices in mixed markets are nearly as *high* as in uniform private-pay markets. (2) Transparency (as compared to opaqueness) leads to *increased* price levels (i.e. decreases competition) in uniform markets, but to *decreased* prices (i.e., increased competition) in mixed markets. This pattern of results is not predicted by prominent models such as Nash equilibrium, reinforcement learning, or fictitious play.

We clearly identify two factors—heterogeneity and transparency of internal incentive structures—which may affect prices and thus profits in a non-obvious way. Awareness of these factors and their effect on prices is of obvious importance to policy makers and managers alike. For example, we find the highest prices in homogeneous transparent private-pay markets, suggesting that similarly structured markets are particularly prone to tacit collusion. Market regulators might want to pay special attention to markets with similar characteristics of competitors. When deciding on the type of incentive structure to adopt, firm managers can be informed by the analysis of the meta games that our results prescribe. Depending on the transparency/opaqueness of the incentive structures, the meta game is either a relatively cooperative stag-hunt game, or a very competitive chicken game. Awareness of the game they are playing is obviously a necessary condition for making well-informed strategic choices vis-a-vis competitors.

In conflicts, be they competitive, political, or bellicose, parties frequently accord a lot of importance to the management of their adversary's knowledge of their own type. In a competitive environment with some non-rational agents, a monopolist can preserve his monopoly by building a reputation of being irrationally aggressive. Conflicting parties also invest large resources to acquire information about their opponent's type. For example, in the negotiations to patch up the Greek debt crisis European governments invested large amounts of scarce time into verifying that the newly elected *Syriza* government was actually trustworthy. However, many strategic decisions have to be taken while acknowledging that one has very limited information about the adversary's decision making process.[10] In our experiment, we assumed that the transparency or opaqueness of the sharing rules is a characteristic of the market, and accordingly both teams in each market are always in the same transparency condition. In real world markets, it is reasonable to assume that transparency is a strategic variable, i.e. a manager can decide whether to make internal structures transparent or to keep them opaque, irrespective of the decision of the competitor. Future research should address under which circumstances it may be optimal for a firm to unilaterally change its transparency policy.

[10] In fact, US Defense Secretary Donald Rumsfeld (2002) might have alluded to this very problem in his famous distinction of "known unknowns" and "unknown unknowns".

Finally, our results have implications for the antitrust literature, particularly for the growing efforts to better understand the behavior and effect of so-called "maverick firms", i.e., firms with a more aggressive pricing policy than their (rather collusive) competitors (Breunig & Menezes, 2008; Eckert & West, 2004). Equal-pay teams in our experiment systematically exhibit maverick firm behavior. Antitrust authorities consider the presence of such maverick firms to be a critical inhibiting element when judging the likelihood of collusion.[11] Our findings suggest that aggressive maverick behavior may be driven by a firm's internal incentive structure, and that the effectiveness of maverick firms in limiting collusion in mixed market may be limited to relatively transparent settings.

[11] The EU Guidelines on the assessment of horizontal mergers 2004, as well as the US horizontal merger guidelines 2010.

Appendix A: Paper Instructions

General instructions for participants

Welcome to our experiment!

If you read the following explanations carefully, you will be able to earn a substantial sum of money, depending on the decisions you make. It is therefore crucial that you read these explanations carefully.

During the experiment there shall be absolutely no communication between participants. Any violation of this rule means you will be excluded from the experiment and from any payments. If you have any questions, please raise your hand. We will then come over to you.

In any event, you will receive a lump sum of 2 euro for taking part in the experiment.

During the experiment we will not calculate in euro, but instead in points. Your total income is therefore initially calculated in points. The total number of points you accumulate in the course of the experiment will be transferred into euro at the end, at a rate of

35 points = 1 euro.

At the end you will receive from us the 2 euro plus the **cash** sum, in euro, based on the number of points you have earned.

Experiment procedure

The experiment consists of **120 periods**.

Prior to the first period, the 24 participants are randomly divided into 8 groups. Each **group** has **3 members**. The same 3 members hence remain in the same group for the entire 120 periods. In addition, each group is randomly assigned to another group. The **other group** that is assigned to yours also remains unchanged for the entire 120 periods. Since the experiment is completely anonymous, you have no possibility of finding out who belongs to your group and who belongs to the other group.

Before the first period begins, the computer will randomly allocate one of two possible **distribution keys** to every group (we will explain below in further detail what these distribution keys look like). The distribution key remains the same for all periods.

At the beginning of each period, you may demand any number of points between 2 and 25 (**individual asking price**). As soon as all participants have stated their individual asking prices, the computer will add up your group's 3 individual asking prices and calculate the **total asking price** of your group. Similarly, the computer will also add up the other group's 3 individual asking prices and calculate the other group's total asking price. The computer will then **compare** the total asking price of your group to the total asking price of the other group.

Distribution key A:

1. If the **total asking price** of your group is **lower** than the total asking price of the other group, then each member of your group receives exactly the number of points he or she demanded (**individual asking price**).

2. If the **total asking price** of your group is **higher** than the total asking price of the other group, then each member of your group receives exactly **0 points**.

3. If the **total asking price** of your group is **equal to** the total asking price of the other group, then each member of your group receives exactly half the points he or she demanded (**half of the individual asking price**).

Distribution key B:

1. If the **total asking price** of your group is **lower** than the total asking price of the other group, then each member of your group receives exactly one-third (1/3) of the total asking price (**total asking price divided by 3**). In other words, the total asking price of your group is evenly distributed among all 3 group members.

2. If the **total asking price** of your group is **higher** than the total asking price of the other group, then each member of your group receives exactly **0 points**.

3. If the **total asking price** of your group is **equal to** the total asking price of the other group, then each member of your group receives exactly one-sixth (1/6) of the total asking price (**total asking**

price divided by 6). In other words, the total asking price of your group is initially halved and then evenly distributed among all 3 group members.

The following table summarizes the two distribution keys once again:

	Distribution key A	***Distribution key B***
1. The total asking price of your group is **lower** than the total asking price of the other group.	You receive exactly your individual asking price.	You receive 1/3 of your group's total asking price.
2. The total asking price of your group is **higher** than the total asking price of the other group.	You receive nothing.	You receive nothing.
3. The total asking price of your group is **equal to** the total asking price of the other group.	You receive exactly half of your individual asking price.	You receive 1/6 of your group's total asking price.

You will be informed, on your computer screen, which distribution key your group has and [but not][12] which distribution key the other group has. As mentioned above, during the entire 120 periods, the distribution key always remains the same.

<u>At the end of each period,</u> you will be given information on:

(a) your individual asking price

(b) your group's total asking price

(c) the other group's total asking price

(d) the number of points earned by you in this period

(e) the total number of points earned by you up to now, including this period.

[12] "and" vs. "but not" is the only difference between the "transparent" condition and the "opaque" condition.

Appendix B: Learning Models

To assess the relative plausibility of the scenarios discussed in the main text, we apply learning models, which are sensitive to the size of the incentive to lower individual bids. We consider two such models: reinforcement learning (Erev & Roth, 1998; Roth & Erev, 1995), a stimulus learning model that takes into account the payoff generated by the player's actions in the past; and fictitious play (Brown, 1951), a belief-based model that takes into account players' beliefs about the future actions of others.

According to reinforcement learning, the likelihood of repeating a specific choice rises after that choice has led to a good outcome ("Law of Effect"; Thorndike (1898)). For the Bertrand duopoly game at hand, experimental evidence (Bornstein et al., 2008; Bornstein & Gneezy, 2002) has largely confirmed predictions derived from reinforcement learning. In line with previous studies, we assume that before the first period each price in the feasible set $X_{ik} \in \{2,3,\ldots,25\}$ is equally likely to be chosen. If the (randomly) chosen price yields a profit, the propensity for choosing the same price again increases, and the increase is proportional to the profit.[13]

We derived the predictions of reinforcement learning by simulating the behavior of 12600 virtual players in 2100 experimental markets. The simulations show that in uniform markets *individual asking prices* increase throughout the repeated interaction in private-pay and decrease in equal-pay markets. In mixed markets the pattern is the same, but the difference between the behavior of private-pay teams and equal-pay teams narrows when they compete on the same market. It follows that according to reinforcement learning, *market prices* in uniform PP markets are higher than in uniform equal-pay markets, and that prices in mixed markets lie in between ("scenario 3").

[13] For the simulation, we use the same parameters as Bornstein and Gneezy (2002) and Bornstein et al. (2008): Initially, every price between 2 and 25 has a weight of 10. After every period the profit earned in that period is added to the weight of the price played. For example: Subject i plays in a private-pay team. In the first period i randomly chooses to bid 8, i's team wins, and i earns 8 points. The updated weight for choosing 8 in the second round is 18 for 8, and the other weights remain unchanged and equal 10.

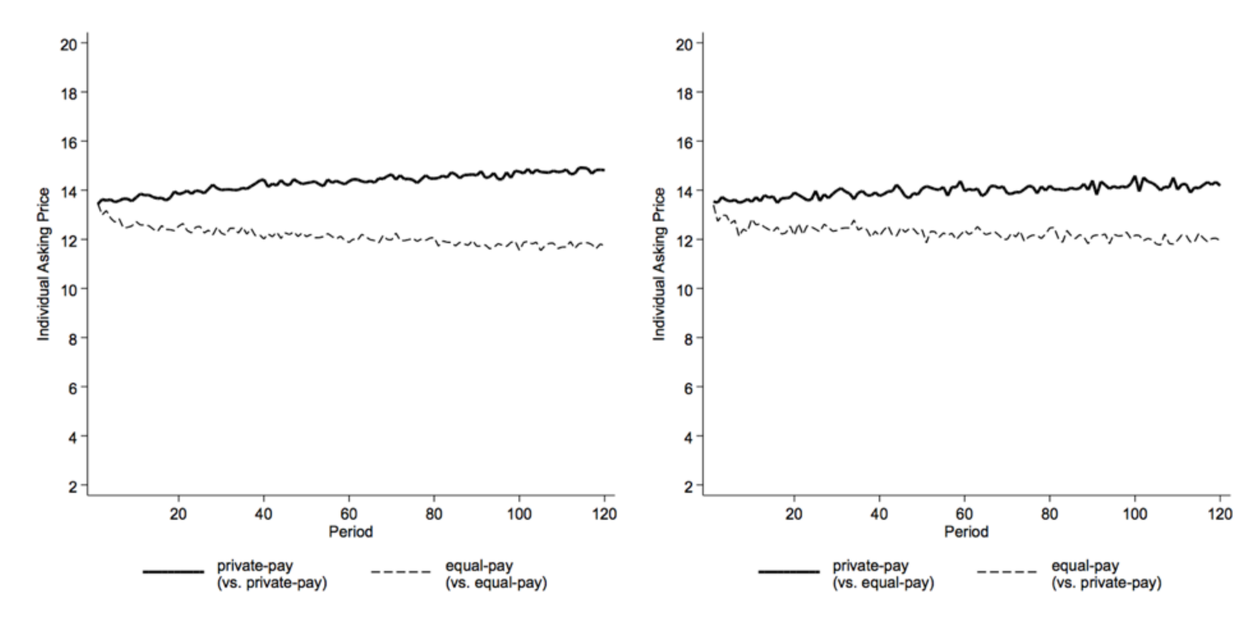

Figure B1: Individual Asking Prices as Predicted by Reinforcement Learning.
The graph on the left (right) depicts the predictions for the uniform (mixed) markets, irrespective of transparency conditions.

Belief-based learning presumes more sophisticated players, that are able to maximize their expected payoffs. The most prominent belief-based learning model is fictitious play (Brown, 1951): a player chooses the action that maximizes her expected payoff based on her beliefs about the future actions of the other players. Beliefs about the other players' future actions are derived from their past actions. Specifically, the more often player j has chosen action X in the past, the higher the probability that player i attaches to player j choosing X in the future. If, for instance player j choose action X in k out of t past periods, player i's belief of j choosing X in the next period would be P=k/t. In the first period, there is no history of past actions, so players pick randomly from the set of feasible actions $X_{ik} \in \{2,3,\ldots,25\}$. As of the second period, players start best responding to the expected actions of the other players.[14]

We simulated the behavior of 360 virtual participants in our experimental markets. Similar to reinforcement learning, fictitious play predicts high prices in private-pay markets, low prices in equal-pay

[14] If there is more than one best responding action, each is equally likely to be picked.

markets, and intermediate prices in mixed markets (in which equal-pay teams win more often). However, in mixed markets fictitious play predicts mainly equal-pay teams to adapt ("scenario 2"). Also counter to reinforcement learning, fictitious play predicts, in all treatments, a decline in asking prices (and thus market prices) over time.

Both reinforcement learning and fictitious play are mute with respect to the effect of transparency on behavior. To the best of our knowledge there are no learning models that are sensitive to the knowledge players have about the payoff function of other players.

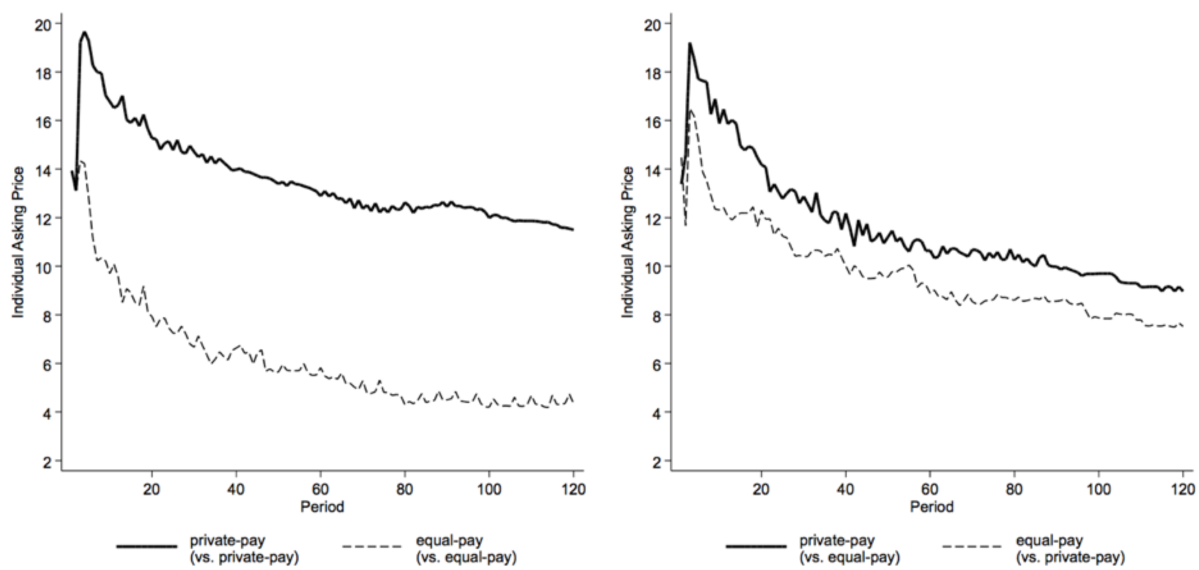

Figure B2. Individual Asking Prices as Predicted by Fictitious Play
The graph on the left (right) depicts the predictions for the uniform (mixed) markets, irrespective of transparency conditions.

References

Abbink, Klaus, Brandts, Jordi, Herrmann, Benedikt, & Orzen, Henrik. (2010). Intergroup Conflict and Intra-Group Punishment in an Experimental Contest Game. *American Economic Review, 100*(1), 420-447.

Alchian, Armen A., & Demsetz, Harold. (1972). Production, Information Costs, and Economic Organization. *American Economic Review, 62*, 777-795.

Argenton, Cédric, & Müller, Wieland. (2012). Collusion in experimental Bertrand duopolies with convex costs: The role of cost asymmetry. *International Journal of Industrial Organization, 30*(6), 508-517.

Bartling, Björn, & von Siemens, Ferdinand A. (2010). Equal sharing rules in partnerships. *Journal of Institutional and Theoretical Economics JITE, 166*(2), 299-320.

Bornstein, Gary, Budescu, David V., Kugler, Tamar, & Selten, Reinhard. (2008). Repeated Price Competition between Individuals and between Teams. *Journal of Economic Behavior & Organization, 66*, 808-821.

Bornstein, Gary, & Gneezy, Uri. (2002). Price Competition Between Teams. *Experimental Economics, 5*, 29-38.

Breunig, Robert, & Menezes, Flavio. (2008). Empirical Approaches for Identifying Maverick Firms. An Application to Mortgage Providers in Australia. *Journal of Competition Law and Economics, 4*(3), 811-836.

Brookins, Philip, Lightle, John P, & Ryvkin, Dmitry. (2015). An experimental study of sorting in group contests. *Labour Economics, 35*, 16-25.

Brown, George W. (1951). Iterative solution of games by fictitious play. *Activity analysis of production and allocation, 13*(1), 374-376.

Cason, Timothy N, Sheremeta, Roman M, & Zhang, Jingjing. (2012). Communication and efficiency in competitive coordination games. *Games and Economic Behavior, 76*(1), 26-43.

Dufwenberg, Martin, & Gneezy, Uri. (2000). Price Competition and Market Concentration. An Experimental Study. *International Journal of Industrial Organization, 18*, 7-22.

Eckert, Andrew, & West, Douglas S. (2004). Retail Gasoline Price Cycles across Spatially Dispersed Gasoline Stations. *Journal of Law and Economics, 47*(1), 245-273.

Erev, Ido, & Roth, Alvin E. (1998). Predicting how people play games: Reinforcement learning in experimental games with unique, mixed strategy equilibria. *American Economic Review*, 848-881.

Farrell, Joseph, & Scotchmer, Suzanne. (1988). Partnerships. *The Quarterly Journal of Economics*, 279-297.

Fischbacher, Urs. (2007). z-Tree. Zurich Toolbox for Ready-made Economic Experiments. *Experimental Economics, 10*, 171-178.

Fugger, Nicolas, Katok, Elena, & Wambach, Achim. (2015). Collusion in dynamic buyer-determined reverse auctions. *Management Science, 62*(2), 518-533.

Greiner, Ben. (2004). An Online Recruiting System for Economic Experiments. In K. Kremer & V. Macho (Eds.), *Forschung und wissenschaftliches Rechnen 2003* (pp. 79-93). Göttingen.

Grether, David M., & Plott, Charles R. (1984). The Effects of Market Practices in Oligopolistic Markets. An Experimental Examination of the Ethyl Case. *Economic Inquiry, 22*, 479-507.

Harbring, Christine, & Irlenbusch, Bernd. (2011). Sabotage in tournaments: Evidence from a laboratory experiment. *Management Science, 57*(4), 611-627.

Hoogendoorn, Sander, Oosterbeek, Hessel, & Van Praag, Mirjam. (2013). The impact of gender diversity on the performance of business teams: Evidence from a field experiment. *Management Science, 59*(7), 1514-1528.

Huck, Steffen, Lünser, Gabriele K, & Tyran, Jean-Robert. (2016). Price competition and reputation in markets for experience goods: An experimental study. *The RAND Journal of Economics, 47*(1), 99-117.

Kräkel, Matthias, & Steiner, Gunter. (2001). Equal sharing in partnerships? *Economics Letters, 73*(1), 105-109.

Lang, Kevin, & Gordon, Peter-John. (1995). Partnerships as insurance devices: theory and evidence. *The RAND Journal of Economics*, 614-629.

Leibbrandt, Andreas, & Sääksvuori, Lauri. (2012). Communication in intergroup conflicts. *European Economic Review, 56*(6), 1136-1147.

Levin, Jonathan, & Tadelis, Steven. (2005). Profit sharing and the role of professional partnerships. *The Quarterly Journal of Economics*, 131-171.

Mason, Charles F., & Phillips, Owen R. (1997). Information and Cost Asymmetry in Experimental Duopoly Markets. *Review of Economics and Statistics, 79*, 290-299.

Nalbantian, Haig R, & Schotter, Andrew. (1997). Productivity under group incentives: An experimental study. *The American Economic Review*, 314-341.

Potters, Jan, & Suetens, Sigrid. (2013). Oligopoly experiments in the current millennium. *Journal of Economic Surveys, 27*(3), 439-460.

Roth, Alvin E, & Erev, Ido. (1995). Learning in extensive-form games: Experimental data and simple dynamic models in the intermediate term. *Games and Economic Behavior, 8*(1), 164-212.

Sääksvuori, Lauri, Mappes, Tapio, & Puurtinen, Mikael. (2011). Costly punishment prevails in intergroup conflict. *Proceedings of the Royal Society of London B: Biological Sciences*, rspb20110252.

Schelling, Thomas C. (1960). *The Strategy of Conflict*. Cambridge,: Harvard University Press.

Shapiro, Carl. (1986). Exchange of Cost Information in Oligopoly. *The Review of Economic Studies, 53*(3), 433-446.

Sheremeta, Roman M. (2015). Behavior in group contests: A review of experimental research. *Available at SSRN 2673275*.

Stigler, George J. (1961). The Economics of Information. *Journal of Political Economy, 69*, 213-225.

-------. (1964). A Theory of Oligopoly. *Journal of Political Economy*, 44-61.

Sutter, Matthias, & Strassmair, Christina. (2009). Communication, cooperation and collusion in team tournaments—An experimental study. *Games and Economic Behavior, 66*(1), 506-525.

Thorndike, Edward Lee. (1898). *Animal Intelligence. An Experimental Study of the Associative Processes in Animals*. New York: Macmillan.

Weber, Roberto A, & Camerer, Colin F. (2003). Cultural conflict and merger failure: An experimental approach. *Management Science, 49*(4), 400-415.

Wilson, Robert. (1968). The Theory of Syndicates. *Econometrica*, 119-132.